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Cost of Clean Air and Water Report to Congress, 1984

Development Planning and
Research Associates, Inc., Manhattan, KS

Prepared for

Environmental Protection Agency, Washington, DC

May 84

U.S. Department of Commerce
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The Cost of Clean Air and Water Report to Congress 1984

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16. Abstract (Limit: 200 words)

The Clean Air Act and Clean Water Act include provisions which require the Administrator of the Environmental Protection Agency to make and report detailed estimates of the costs of carrying out the respective Acts. This report presents such estimates as two separate reports, one concerned with the control of air pollution, the other concerned with the control of water pollution. This summary provides information on both reports and presents listings of the "Water costs","Air costs", and "combined costs."

This report includes only those costs associated with federal regulatory actions resulting from the Clean Air and Water Acts, and does not account for costs voluntarily incurred by polluters, required by the State or local governments only, or mandated by other Federal laws. It does not include costs incurred prior to the dates of the respective Acts (Air--1970, Water-1972).

Preparation for this report was begun in 1980 and completed in 1983. It reflects, for the most part, the regulatory framework existing in December, 1982. The 1981 annualized cost of pollution control due to federal regulations was estimated to be $42.5 billion or about 1 percent of GNP in 1981. The cumulative cost from 1970 to 1978 was $171 billion and the projected cost over the period 1981-1990 is estimated at $525.8 billion.

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Pollution control costs, air pollution costs, water pollution costs, investment costs, operating and maintenance costs, economic impacts industry costs, government costs, energy industries, chemical industries, metals industries, mineral-based industries, manufacturing and services industries, forest and agricultural industries, solid waste reduction industries.

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HAZARDOUS WASTE HEALTH RESEARCH

esp for mixtures

GOAL: TO DEVELOP AND VALIDATE TWO HUMAN HEALTH EFFECT BIOLOGICAL TEST PROTOCOLS FOR USE IN RAPIDLY AND INEXPENSIVELY SCREENING MANUFACTURING RESIDUE WASTES FOR POTENTIAL HEALTH HAZARDS:

- A PRE-SCREEN PROTOCOL TO GIVE A RAPID QUALITATIVE (YES-NO) APPRAISALS OF TOXICITY.
- A CONFIRMATION SCREEN TO PROVIDE A PRELIMINARY QUANTITATIVE ESTIMATE FOR PRIORITIZING HUMAN HEALTH RISK.

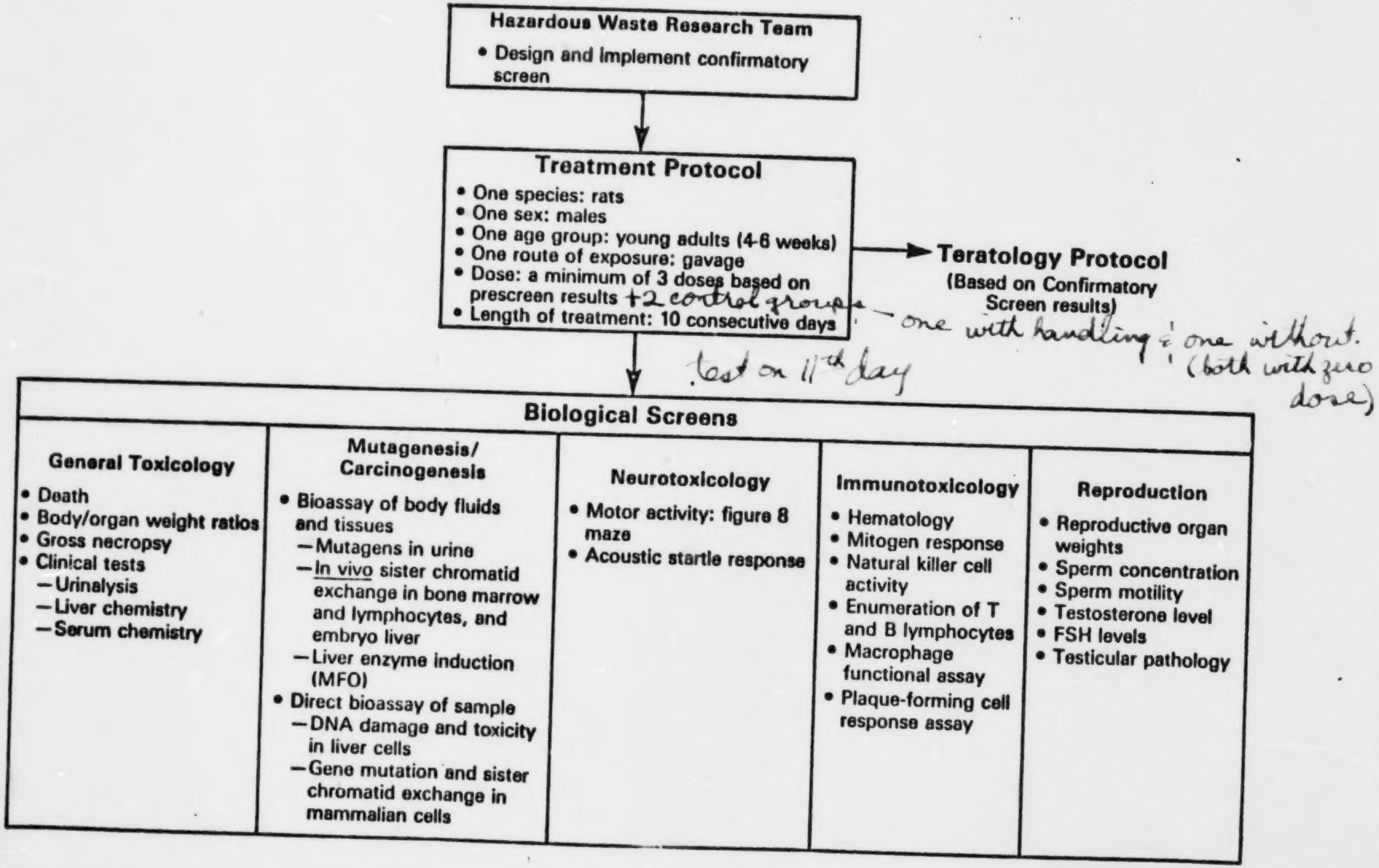
RATIONALE: THIS WORK IS BEING DONE TO IMPROVE THE SCIENTIFIC AND TECHNICAL BASIS FOR REGULATORY AND ENFORCEMENT ACTIVITIES IN EPA. SPECIFICALLY:

- SECTION 3001 OF THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) REQUIRES EPA TO PROMULGATE CRITERIA FOR IDENTIFYING THE CHARACTERISTICS OF HAZARDOUS WASTES AND LISTING HAZARDOUS WASTES.

- BECAUSE OF THE LARGE NUMBER OF WASTES TO BE SCREENED, OSWER NEEDS A RAPID, INEXPENSIVE BIOASSAY TO USE IN PRIORITIZING WHICH WASTES ARE MOST IMPORTANT FOR TOXICOLOGICAL CHARACTERIZATION AND WHERE THEY SHOULD INVEST LIMITED RESOURCES.

HAZARDOUS WASTE - HEALTH RESOURCES

	FY'84	FY'85	FY'86
FTE	8.0	8.0	12.0
S&E	377.9	756.4	780.0
R&D	586.9	586.9	1412.0
	964.8	1343.3	2192.0



Hazardous Waste Research Team

- Design and implement confirmatory screen

Treatment Protocol

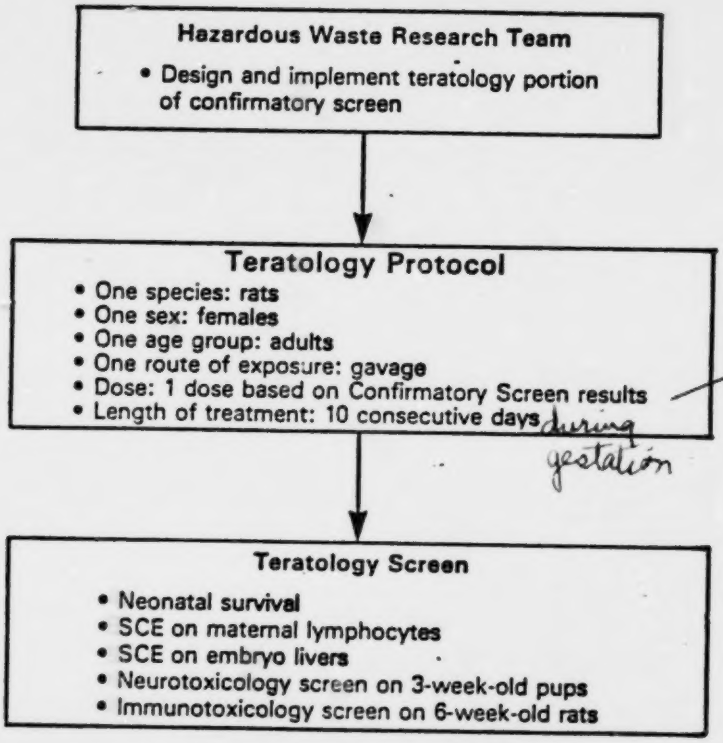
- One species: rats
- One sex: males
- One age group: young adults (4-6 weeks)
- One route of exposure: gavage
- Dose: a minimum of 3 doses based on prescreen results +2 control groups — one with handling & one without. (both with zero dose)
- Length of treatment: 10 consecutive days

Teratology Protocol
(Based on Confirmatory Screen results)

test on 11th day

Biological Screens

General Toxicology	Mutagenesis/ Carcinogenesis	Neurotoxicology	Immunotoxicology	Reproduction
• Death • Body/organ weight ratios • Gross necropsy • Clinical tests —Urinalysis —Liver chemistry —Serum chemistry	• Bioassay of body fluids and tissues —Mutagens in urine —In vivo sister chromatid exchange in bone marrow and lymphocytes, and embryo liver —Liver enzyme induction (MFO) • Direct bioassay of sample —DNA damage and toxicity in liver cells —Gene mutation and sister chromatid exchange in mammalian cells	• Motor activity: figure 8 maze • Acoustic startle response	• Hematology • Mitogen response • Natural killer cell activity • Enumeration of T and B lymphocytes • Macrophage functional assay • Plaque-forming cell response assay	• Reproductive organ weights • Sperm concentration • Sperm motility • Testosterone level • FSH levels • Testicular pathology



Hazardous Waste Research Team

- Design and implement teratology portion of confirmatory screen

Teratology Protocol

- One species: rats
- One sex: females
- One age group: adults
- One route of exposure: gavage
- Dose: 1 dose based on Confirmatory Screen results — max tolerated dose
- Length of treatment: 10 consecutive days during gestation

Teratology Screen

- Neonatal survival
- SCE on maternal lymphocytes
- SCE on embryo livers
- Neurotoxicology screen on 3-week-old pups
- Immunotoxicology screen on 6-week-old rats

Selection of Pure Compounds

- Positive controls for each biological end point
- Negative controls for each biological end point
- Selection based on subchronic (90-day) and chronic studies

↓

Selection of Concentrations of Exposure for Pure Compounds

- Selection based on 14- or 90-day studies

↓

Final Statistical Design of the Study

↓

Commence Exposure of Test Animals to Several Concentrations of the Pure Compounds

- Determine biological end points

↓

Evaluation of Dose Response Data

- Determine positive and negative response for each biological end point

↓

Statistical Evaluation of Test Performance

↓

Selection of Final Prescreen Protocol

↓

Initial Implementation and Evaluation of Prescreen Protocol with Several Waste Samples

INITIAL CHEMICALS SELECTED FOR VALIDATION STUDY (FY 84)

CHEMICAL	POSITIVE CONTROLS	COMPLETION DATE
1. CYCLOPHOSPHAMIDE	M/C R I	1/84
2. CHLORDECONE	N R T G	4/84
3. ACRYLAMIDE	G N	5/84
4. DIETHYLSTILBESTEROL	C R I	7/84

LEGEND

M	MUTAGENESIS
C	CARCINOGENESIS
R	REPRODUCTIVE TOXICITY
T	TERETOGENESIS
N	NEUROTOXICITY
G	GENERAL TOXICITY
I	IMMUNOTOXICITY

Risk Assessment - Summary Sheet

Key Question: What new or improved risk assessment information and tools does OSWER need for more effective regulatory, permitting, enforcement, emergency, and remedial decisions?

Reason for Concern:

- Technical support in health assessments is required.
- There are no rapid and inexpensive methods for characterizing health hazards of complex unknown chemical mixtures in manufacturing residue wastes.
- Bioassay screening protocols are needed for use in prioritizing which wastes are most important for toxicological characterization because of the large number of wastes to be evaluated.
- Screening protocols are essential tools for determining where limited resources should be invested.
- Inadequate data and tools are available to predict the impact of releases of hazardous wastes from accidental spills, landfills, surface impoundments, and other sources on various environmental media, especially ground water.
- Structure-Activity Relationships, along with bioassays, can provide rapid and inexpensive screening methods.
- Ocean dumping should be considered as an alternative to other ultimate disposal methods.

Clients:

- Section 3001 RCRA listing/delisting program
- Section 3004 RCRA land disposal regulatory program
- Section 3005 RCRA permitting program
- Waste Programs Enforcement
- Superfund

ORD Laboratories:

- Environmental Criteria and Assessment Office - Cincinnati
- Health Effects Research Laboratory - Research Triangle Park and Cincinnati
- Robert S. Kerr Environmental Research Laboratory - Ada
- Environmental Research Laboratory - Athens
- Environmental Research Laboratory - Duluth
- Environmental Research Laboratory - Narragansett

Risk Assessment - Current Activities

I. Office of Health and Environmental Assessment (OHEA)

A. Provide Health Effects Assessments

1. Health and Environmental Effects Profiles (HEEPs)
2. Reviews for mutagenicity and reproductive effects
3. Cancer assessments

B. Establish Risk Assessment Methodologies

1. Complex mixtures
2. Mutagenicity and infertility

II. Office of Health Research (OHR)

A. Validation of the Confirmatory Screening Protocol (Characterization)

1. General Toxicology
2. Mutagenesis/Carcinogenesis
3. Neurotoxicity
4. Immunotoxicity
5. Reproduction
6. Developmental Toxicology
    a. Teratology
    b. Neurotoxicity

B. Develop Prescreen Protocol (Detection)

It will consist of the most sensitive tests selected from the validation protocol. The prescreen testing matrix will be predictive of adverse human biological activity (qualitative; yes-no) and of the need for further testing.

III. Office of Environmental Processes and Effects Research (OEPER)

A. Qualitative Structure-Activity Relationships (ERL-Duluth)

1. Develop systematic data base - toxicity and bioaccumulation
2. Prediction of chemical mixture toxicity
3. Pharmacodynamic studies of toxicity
4. Surrogate species - fish/mammalian dose-response relationships

B. Ground Water (RSKERL-Ada)

1. Determination of waste mobility by use of microcosms
2. Risk assessment by hydrogeological classification
3. Development and evaluation of ground-water models

C. Multimedia Processes and Modeling (ERL-Athens)

1. Methods development
2. Processes research
3. Model integration and development

D. Ocean Dumping (ERL-Narragansett)

1. Hazard assessment protocol
2. Waste evaluation protocol

D 109 Hazardous Waste

Title: Risk Assessment

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE / Total $ (R&D) 84	FTE / Total $ (R&D) 85	Long-Term 86	Long-Term 87
OHEA	A70	Health Effects Assessment	15.1 1250.7 (576.6)	17.6 1106.0 (261.0)		
		o Health and environmental effects profiles (HEEPs) for approximately 100 chemicals in FY-84, and for about 130 chemicals in FY-85				
		o Data summaries, as requested, to assess the need for development of HEEPs				
		o Summarized assessments of chronic and subchronic toxicity, as requested				
	A71	Risk Assessment Methodology	4.5 246.7 (48.6)	2.5 275.5 (150.5)		
		o Reports on the modification of health risk assessment methods to reflect the influence of less than lifetime exposure and exposure of sensitive subpopulations				
		o Reports on modification of methods for conducting health risk assessments to incorporate developments in the areas of chemical structure-activity relationships, metabolism studies, and prediction of physical and chemical parameters from chemical structure				

X

D 109 Hazardous Waste

Title: Risk Assessment

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE Total $ (R&D) 84	 85	Long-Term 86	 87
OHR	01	Develop and Evaluate Prescreen and Confirmation Screen	8.0 964.8 (586.9)	8.0 1343.3 (586.9)		
		◦ Journal article on integrated prescreen validation studies				
		◦ Research report on final evaluation of the prescreen protocol				
		◦ Report on evaluation of the confirmation protocol for integrated toxicological screen				

D 109 Hazardous Waste

Title: Risk Assessment

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE Total $ (R&D) 84	85	Long-Term 86	87
OEPER (Duluth)	A23	Bioassays and Predictive Methods for Listing/Delisting (Quantitative Structure-Activity Relationships)	20.0 1127.5 (399.0)	20.0 1443.3 (543.3)		
		o Report on hazardous waste leachate chemical screening system				
		o Journal article on joint action of multiple organic toxicants to freshwater organisms				
		o Report on methods for determining toxicant uptake and mode of action				
		o Report on feasibility of the surrogate species approach				
		o Report on a QSAR based predictive model for toxicity of individual chemicals				
		o Journal article on determination of model of toxicity for key chemical classes				
		o Report on fish/mammalian dose-response relationships				

D 109 Hazardous Waste

Title: Risk Assessment

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE / Total $ (R&D) 84	FTE / Total $ (R&D) 85	Long-Term 86	Long-Term 87
OEPER (Ada)	A24	Screening Methods for Environmental Mobility of RCRA Wastes	2.5 385.0 (165.)	4.0 447.0 (185.0)		
		o Report on utilization of microcosms for determining transport and fate parameters				
	B25	Prediction of Environmental Concentration of Hazardous Wastes	5.1 1130.3 (714.9)	8.2 1429.6 (1000)		
		o Jour. art. on sensitivity analysis of model parameters				
		o Final report to OSW on computer simulation of selected ground-water contamination scenarios				
	C26	Criteria and Guidelines for Site Evaluations	1.0 188.0 (100)	0 0		
		o Report to OSW on hydrogeological classification protocols				

Title: Risk Assessment

D 109 Hazardous Waste

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE Total $ (R&D) 84	 85	Long-Term 86	 87
OEPER (Athens)	B28	Evaluation of Waste Management Alternatives (Multimedia Processes and Modeling)	11.5 807.8 (360.0)	11.5 802.4 (200)		
		Chemical Characterization of Leachates, Soils and Sediment				
		◦ Jour. art. on improved GC/MS method for identification of haz. waste components				
		◦ Jour. art. on ion chamatographic techniques for analysis of metals and an ions in water				
		◦ Jour. art. on application of MAS to haz. waste leachates				
		◦ Jour. art. on application of Solids MAS to haz. waste sites				
		Fate Processes				
		◦ Report on effects of high chemical concentrations on terrestrial and aquatic environments				
		◦ Jour. art. on kinetics of abiotic redox transformation for an organic cpd.				
		◦ Report on computational procedures for predicting changes in sorption as a function of solvent properties				

Title: Risk Assessment D 109 Hazardous Waste

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE Total $ (R&D) 84	85	Long-Term 86	87
OEPER (Athens) cont.	B28	Multimedia Management Model				
		◦ Interim report on residuals management analysis framework				
		◦ Interim user's manual on screening methodology for estimating organics from uncontrolled sites				
		◦ Report on results of ground water modeling of selected setting to determine leachate migration (with OSW)				
		◦ Post closure liability assessment methodology (with MERL and OSW)				
		◦ Case study report on the analysis of integrated residuals management				

Title: Risk Assessment D 109 Hazardous Waste

Research Objective: Provide new or improved risk assessment information and tools for more effective estimates of the degree of hazard to public health and/or the environment which has resulted or could result from deliberate or accidental release of substances into the environment.

ORD Office	PPA #	Activities/Deliverables	FTE Total $ (R&D) 84	 85	Long-Term 86	 87
OEPER (Narr)	B29	Hazard Assessment Protocol to Evaluate Ocean Dumping Impacts				
		◦ Report on evaluation of effects assessment methods for dredged materials	3.0 135.0 (0)	0 0	—	—
		◦ Final report on hazard assessment methods for evaluating ocean dumping impacts				
		◦ Report on exposure assessment component of dredged material case study				
		◦ Exposure assessment methodologies for dredged material contaminants in central Long Island Sound				
	B30	Protocols for Evaluating a Waste Proposed for Ocean Dumping				
		◦ Report on waste evaluation of dredged material	1.0 45.0 (0)	0 0		
		◦ Report on waste evaluation of industrial wastes				

SOLID WASTE (D109)

PROPOSED FY-86 RISK ASSESSMENT PROGRAM

OHEA (Scientific Assessments)	---R&D $K--- FY 85	FY 86
- Prepare detailed health and environmental assessments (including carcinogenicity/reproductive effects and exposure assessments) to support RCRA Sect. 3001	138	138
- Prepare health and environmental effects profiles for approximately 130 chemicals.	123	123
- Develop ADIs for inhalation exposures associated with alternative disposal technologies such as incineration	0	25
- Conduct a feasibility study to determine what procedures/endpoints may be available to provide input to methods development for exposure and risk assessment for alternative disposal technologies such as physical/chemical neutralization, biodegradation, or incineration	0	27
- Develop modified methods for conducting health risk assessments to incorporate developments in the areas of chemical structure-activity, relationships, metabolism studies, and prediction of physical and chemical parameters from chemical structure.	150.5	150.5
- Develop methodologies to monitor humans for genetic damage and correlate with test animal studies for improving risk assessment extrapolation procedures for cancer and mutagenicity.	0	216
- Estimation of cancer responses as a function of long-term and short-term exposures to hazardous waste constituents.	0	164
- Perform an examination of dose response and reversibility of promoters and cocarcinogens which may be constituents of hazardous wastes	0	109

	FY 85	FY 86
- Develop standard scenarios to evaluate human exposure to hazardous wastes.	0	27
- Develop methods to account for absorption of hazardous chemicals and mixtures (via GI tract, lungs, skin) for use in exposure calculations, to assure comparability with methods used in the calculation of cancer potencies.	0	55
- Research on the estimation of human exposure to hazardous chemicals resulting from dilution through commercial preparation/production and marketing practices.	0	27
- Develop methods and procedures for performing sensitivity analyses to identify parameters having the most impact on exposure assessment	0	55
- Evaluate the use of surrogate compounds to estimate rates of absorption and desorption of broad classes of chemicals in biota which impact human exposure	0	110
- Evaluate experimental data on chemical absorption and desorption by fish to provide estimates of time required by fish to equilibrate with environmental	0	110
OHEA TOTAL	411.5	1336.5

OHR (Health Effects)

	FY 85	FY 86
- Develop and validate confirmatory screening protocol for characterization and listing of hazardous wastes	350	662.7
- Develop and validate prescreen protocol for detecting potentially adverse health effects from manufacturing residues	236.9	750
OHR TOTAL	586.9	1412.7

Environmental Processes and Effects (EPE)

	FY 85	FY 86
Quantitative Structure Activity Relationships		
- Develop Model for Predicting Toxicity and Bioaccumulate Potential from Structure	132	132
- Joint Action of Multiple Toxicants	200	200
- Surrogate Species: Fish/Mammalian dose-response relationship	161	200
- Pharmacodynamic studies of modes of toxic action	50	100
- Development of Bioassay Data for OSW selected chemicals (new start)	0	300
QSAR TOTAL	543	932
Ground Water		
- Develop and Test Protocols for Using Microcosms	185	385
- Field Verification of Transport Models	921	920
- Determination of Threat to Ground Water by Metals	80	0
- Evaluate Current Models for Transport of Metals	0	120
- Determination of Fate of Dioxin in Ground Water	150	150
Ground Water Total ...	1336	1575
Multimedia Processes and Modeling		
- Methods Development for Process Characterization	95	75
- Fate Processes of Hazardous Wastes	90	265
- Waste Management Models	175	200
Multi Media Total	360	540
EPE TOTAL	2239	3047

March 29, 1984

HAZARDOUS WASTE RESEARCH PROGRAM AT ATHENS ENVIRONMENTAL RESEARCH LABORATORY

The development and testing of environmental exposure assessment techniques and data, and technical support in their application by OPTS under TSCA and FIFRA are major activities of Athens ERL. Building upon this expertise, the methodology previously developed for OSW use in assessing likely exposures of over 200 candidate hazardous wastes and our chemical characterization capability, Athens ERL is developing integrated environmental exposure assessment techniques and protocols for characterizing the chemical nature of environmental threats from hazardous wastes, for predicting their environmental transport and transformation, including intermedia exchanges, and for evaluating the environmental consequences of proposed hazardous waste control or management strategies. This development will entail the following functions and activities:

- Chemical characterization of environmental threats from hazardous wastes. Characterization and quantification of chemical contaminants that may reach soil, water and air from disposal of hazardous wastes are a prerequisite to making environmental exposure assessments. Disposal of complex, unknown mixtures of organic and inorganic chemicals and the diverse environment components (soil, sediment, sludges, leachates, surface water, air, and biota) that may be affected pose particularly challenging scientific problems in developing chemical characterization techniques. Specific objectives of this R&D include: (1) development of separation and extraction procedures for organic and inorganic contaminants; (2) development of analytical methods to characterize inorganic species as well as organic contaminants; (3) adaptation and improvement of computer-based spectroscopy techniques, e.g., GC/MS and GC/FTIR for the characterization and analysis of hazardous chemical contaminants; (4) development of HPLC methods, using a variety of specific and spectroscopic detectors for analyzing non-volatile organics in hazardous waste; (5) characterization of soils with respect to their redox potential and chemical reactivity.

- Environmental process information. The mechanisms and kinetics of organic and inorganic chemical reactions, biodegradation and transport processes in soil, water and sediment for environmental chemical contaminants from hazardous wastes are poorly understood. The influences of external environmental (pH, eH, termperature, fluctuating moisture content, and synergistic effects of other chemicals) and matrix parameters (influence of high concentrations of hazardous waste constituents on the physical, chemical, and biological properties of the soil matrix) in soil, water, and sediment must be quantified if expected environmental concentrations of contaminants and their reaction products are to be predicted. This information is particularly crucial for the future development of an evaluative exposure assessment tool for evaluating disposal sites or alternative remedial measures. Specific research objectives include: (1) information on abiotic transformations of organic chemicals associated with subsurface conditions, (2) information on the influence of subsurface conditions on the kinetics of adsorption and desorption; and (3) information on nature and reactivity of amorphous oxides with respect to metal equilibria and kinetics.

- Exposure assessment methods. Computer-based chemical transport and transformation algorithms are needed similar to those being developed for pesticide and toxic exposure assessment that take into account multimedia chemical transport. A specific objective for FY86 is to have ready a multimedia exposure assessment tool so that alternative disposal techniques, such as incineration, landfills, lagoons, land spreading, and direct air or water discharge, may be assessed for potential multimedia exposures of hazardous waste components. A screening methodology for estimating organics pollutant release from uncontrolled waste site (interim users manual) was planned for FY84 and will be completed this fiscal year.

- Socio-economics. There is increasing awareness of the need and value of cost, risk, and benefit information as part of the decision-making process of hazardous waste management. The specific objective will be to complete the development of economic criteria for evaluating the tradeoffs (including risks, benefits, and costs) of alternative hazardous waste management options from a multimedia perspective and a case study to evaluate the economic criteria for making such tradeoffs.

The program outlined is tailored to the projected available resources of 9 FTEs and $540K in extramural resources excluding the initiative. Accelerated or more comprehensive research would require additional funds. Provision of direct support in characterizing and assessing chemical threats would require additional workforce and funds depending on the extent of effort desired.

The chemical characterization work will have direct applicability and input into the chemical characterization methodology needs of the Superfund Program. Some carryover of information in the area of environmental exposure assessment method development and environmental process information is also expected.

In FY86 attention will be directed to: (1) continued development and refinement of the chemical characterization techniques; (2) an enhanced understanding of the environmental processes influencing the transformation mechanisms, kinetics, and pathways; (3) multimedia screening and design exposure assessment methodologies for evaluating alternative disposal options or for new site selection options; and (4) construction and operation of an experimental four-cell land disposal system for conducting systematic process-level investigations on the factors (waste and site characteristics) that contribute to leachate quality (6 FTE's, $775K S&E, and $700K R&D resources). See attachment for detailed discussion of the initiative, "Leachate Quality and Predictive Modeling".

Draft

Leachate Quality and Predictive Modeling for

Hazardous Waste Facilities: Research Initiative

Athens Environmental Research Laboratory
Athens, Georgia 30613
March 26, 1984

George W. Bailey
FTS-250-3307

Research Initiative
Leachate Quality

Background

Land disposal systems for hazardous wastes are intended to prevent migration of waste constituents to adjacent ground and surface waters. The siting, design, permitting, exclusions, compliance monitoring, and leakage corrective actions require a combination of both predictive modeling of leachate quality and sampling for indicator and specific constituents. Existing regulations specify certain monitoring protocols, give rationale for issuing variances in permits, and set limits of contamination for which corrective action is required. The problem remains, however, to anticipate future problems and enhance the success of corrective actions by relating waste characteristics, environmental and design factors, and existing monitoring data to the ultimate quality, fate, and transport of leachate. In other cases, questions of liner compatibility and monitoring system design usually depend on projected leachate characterization. The time span of interest must include the life of the facility, closure, and post closure and thus will exceed 30-50 years in most cases.

Landfills, lagoons, and land treatment systems present potential waste migration problems. Lagoons and land treatment units are accelerated treatment systems, are required to monitor both unsaturated and saturated zones and the lagoon contents including liners are completely removed at closure. The greatest uncertainty over several decades, then, exists for landfills. Therefore, this initiative is directed to develop and test methods to predict leachate quality from landfills.

Data Needs and Alternative Research Approaches

A two-pronged research approach is proposed. The first approach, outlined in the attached document prepared by MERL-Cinc., proposes to conduct specific characterization studies at existing, operating landfill sites. Existing models developed by OSW and the Athens ERL will be tested to the extent possible with the data to be collected in the study. A second approach, to be specified in the next section, proposes the construction and operation of an experimental, four-cell, land disposal system for the purpose of conducting systematic, process-level investigations on the factors that contribute to leachate quality. This system is intended to be the counterpart, in concept, to the similar facility developed at the R.S. Kerr Environmental Research Laboratory to investigate land treatment processes.

MERL--

A systematic data base characterizing leachate quantity, quality (specific waste constituent concentrations), and input waste characteristics collected from completely characterized systems is desired. The direct extrapolation potential of the data base may be limited because of the site-specific nature of the systems monitored, the lack of precise knowledge of the *in situ* conditions, and the short time frame of the measurements vis-a-vis the operation, closure, and post-closure time frames. Nevertheless, a systematic characterization of leachate quality at existing facilities could provide useful information when combined with test leaching procedures (e.g., EP, batch, column tests). Empirical approaches to leachate predictions could be developed from such an effort and existing, lumped-parameter approaches can be tested.

AERL--

Successful predictive projections for leachate quality may ultimately rest on the ability to relate the physicochemical characteristics of the input wastes, in situ wastes and admixtures, engineered system components (liners, drains, etc.), and the prevailing environmental factors in a deterministic, process-based model. The development and testing of such a model can substantially reduce the prevailing uncertainty about failure rates, environmental contamination, and human health risks from off-site exposure, both in the near-term and post closure. Process understanding at this level will also enhance the interpretation of monitoring data. For example, the measured constituents can indicate the degree of treatment achieved, anticipated future breakthrough of other constituents, and other important indicators. Finally, design procedures can be substantially refined to further prevent future migrations during post closure periods.

AERL Research Proposal

A four-cell, multi-layered land disposal system will be constructed and fully instrumented. The system will be designed to enable complete measurement and characterization of the leachate quality, hydraulic, and gas transport aspects of such systems. The basic idea is to enable accelerated but carefully controlled field experiments to be conducted in conjunction with laboratory studies on process chemistry, reactions, and product identifications. Chemical constituents of low toxicity and other hazard potential (both organic and inorganic) will be selected to provide valid scientific data but to avoid the requirement to operate the system as an actual "hazardous" facility. The Athens ERL extensive experience in field studies (including leaching studies), process chemistry, model development, and analytical chemistry methods development will be brought to the problem through a combination of inhouse and extramural tasks.

Resources (Athens ERL only)

	FY86	FY87	FY88	FY89
FTE's	6.0	6.0	6.0	6.0
S&E	775.0*	775.0*	600.0	600.0
R&D	700.0	700.0	700.0	700.0
Totals	1475.0	1475.0	1300.0	1300.0

*These funds include facility construction costs

Outputs

The following specific outputs are anticipated from the Athens ERL research. Additional, related outputs from other joint work with MERL may be found elsewhere.

o	Completion of an experimental facility to investigate leachate quality	FY86
o	Chemical characterization of site and admixtures	FY87/88
o	Hydraulic and gas transport model for land fill systems	FY87
o	Report(s) on process chemistry of in situ behavior of land-disposed wastes	FY87/88
o	Report comparing results of standardized leaching/extraction testing against detailed experimental data on test leachates	FY87/88
o	Predictive model(s) for leachate quality and gaseous emissions from landfills	FY87/88
o	Model testing results and uncertainty limits for leachate quality and gas emissions models	FY88
o	Recommendations for monitoring protocols and design changes for landfills	FY88

FINAL REPORT

THE COST OF CLEAN AIR AND WATER

REPORT TO CONGRESS

1984

May 1984

U.S. Environmental Protection Agency
Office of Policy Analysis
Washington, D.C.

Contractor:

Development Planning and Research Associates, Inc.

in association with

TCS Management Group, Inc.
and
Pope-Reid and Associates, Inc.

REPORT OF THE ADMINISTRATOR
OF THE
ENVIRONMENTAL PROTECTION AGENCY
TO THE
CONGRESS OF THE UNITED STATES
IN COMPLIANCE WITH

SECTION 312(c) OF THE CLEAN AIR ACT, AS AMENDED BY PUBLIC
LAW 91-604, THE CLEAN AIR AMENDMENTS OF 1970

AND

SECTION 516(b) OF PUBLIC LAW 92-500, THE FEDERAL WATER POLLUTION
CONTROL ACT AMENDMENTS OF 1972

EXECUTIVE SUMMARY

The Clean Air Act and Clean Water Act include provisions which require the Administrator of the Environmental Protection Agency to make and report detailed estimates of the costs of carrying out the respective Acts. This report presents such estimates as two separate reports, one concerned with the control of air pollution, the other with the control of water pollution. This summary provides information on both reports and presents listings of "water costs," "air costs," and "combined costs."

This report includes only those costs associated with federal regulatory actions resulting from the Clean Air and Clean Water Acts, and does not account for costs voluntarily incurred by pollutors, required by State or local governments only, or mandated by other federal laws. It does not include costs incurred prior to the dates of the respective Acts (Air--1970, Water--1972) (nor expenditures which would have taken place if the Acts had not been passed).

This document specifically does not represent EPA policy concerning the application of presently available or projected emissions-control technology to any industry or activity. To estimate the cost of complying with EPA regulations to the industries included in the report, it was necessary to make simplifying assumptions. Thus, the control technologies assumed in providing these estimates are not to be regarded as specifically required by law nor by EPA. Moreover, cost estimates included in this study may differ from cost estimates included in other studies because of differences in definition of the industries.

The costs reported for the control of air pollution are, for the most part, based on compliance with federally-approved State Implementation Plans, federal New Source Performance Standards, and federal regulations for mobile sources. The costs reported for the control of water pollution are, for the most part, based on compliance with federal Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards. Regulations for hazardous and toxic pollutants are also included.

Preparation for this report was begun in 1980, and completed in 1983. It reflects, for the most part, the regulatory framework existing in December 1982.

In the air report, the cost of regulations implementing the Clean Air Act Amendments of 1977 are not estimated separately, except where information was available from a detailed industry study. It is difficult to assess the costs of complying with BACT (Best Available Control Technology) and LAER (Lowest Available Emission Rates) because these requirements are source-specific. (BACT and LAER govern emissions from certain new sources in attainment and non-attainment areas respectively.) NSPS costs were frequently used as an approximation for BACT or LAER costs.

No information was available concerning the cost of complying with BART (Best Available Retrofit Technology) standards, which apply to certain sources in designated attainment areas. Except where NESHAPS (National Emissions Standards for Hazardous Air Pollutants) are involved, there is also very little information available on fugitive emission control costs. The report does not include cost estimates for most fugitive emission controls.

In the water report, some of the regulations proposed or promulgated in accordance with the 1976 Consent Decree with the National Resources Defense Council have not been incorporated in the cost estimates. It is difficult to assess the impact of certain expected regulatory changes on the control costs included in this report. The Clean Water Act of 1977 (amending the Federal Water Pollution Control Act of 1972) will require less stringent controls for conventional pollutants than in the past. However, additional regulations promulgated in accordance with the 1976 NRDC Consent Decree will result in more stringent guidelines for certain industries. More detail is provided regarding the costs included in this report and future regulatory changes in the Introductions to the Air Report and Water Report.

COST OF IMPLEMENTING THE ACTS

The base year for the costs presented here is 1981; all costs are expressed in millions of 1981 dollars. The report includes estimates of investment and annual costs for two historical periods: 1970-81 (Air), 1972-81 (Water) and projections of these costs for the period from 1982 through 1990.

The costs reported include:

- Capital costs of equipment and installation
- Annual capital costs (sum of equivalent annual cost or current and previous years capital expenditures)
- Direct operating and maintenance costs.

The methodology used to generate costs is discussed in the introduction of each report and in more detail in the specific chapters. The methodology involves the analysis of specific regulations for affected sectors of industry and the development of cost estimates for the control equipment or methods characteristic of each sector.

The estimates of the costs are engineering estimates; they are not obtained from industry surveys. The estimates are based on the assumed application of existing technology, and are developed by various techniques such as the use of "model" plants, or actual data on an existing plant. Various other assumptions are used, such as the selection of an "average" air-pollution regulation typical of all State Implementation Plans. The assumptions probably result in an overstatement of costs, since no allowances are made for technological innovation, which might reduce the costs of pollution control.

A summary of the findings is included in the three following tables. Table 1 presents estimated total air and water pollution control costs, Table 2 presents estimated air pollution control costs, and Table 3 presents estimated water pollution control costs. The tables show both investment costs and annual costs. (Annual costs include annualized capital costs and operating and maintenance costs.)

Major industry groups are consistent among these tables; however, individual line items are presented only where costs have been developed. Some industries have only air or only water costs associated with them and so appear in only one of the last two tables. Table 1 is the sum of Tables 2 and 3. For example, the table entry for Mobile Sources appears in Tables 1 and 2 as an air pollution item. A key at the end of this summary explains how the individual industry chapters were grouped in these summary tables.

The government expenditures shown in the tables are based on expenditures to run pollution control programs at the federal, state, and local levels and the projected distribution of grants for construction of municipal water treatment plants. Program operating costs are included for both air and water pollution control with "Annual Costs" in both Tables 2 and 3; the construction grants are included with "Investment" in Table 3, with annualized capital costs of the grants included with the "Annual Costs" shown in Table 3.

Various major industries appear as single entries because of their significance in terms of pollution control costs, such as electric utilities, petroleum refining, iron and steel, primary aluminum and copper, and pulp and paper. The Mobile Sources category includes passenger cars, light and heavy-duty gasoline and diesel trucks, aircraft, and motorcycles.

Further details on any group may be found via the key to aggregation given at the end of this summary, or the individual chapters of the report.

COMPARISON OF COSTS

In terms of the combined costs given in Table 1, the highest levels of expenditures are associated with the Energy Industries (largely electric power plants and petroleum refining) and Mobile Sources.

The 1981 annualized cost of pollution control due to federal regulations was estimated to be $42.5 billion, or about one percent of GNP in 1981. The cumulative cost from 1970 to 1978 was $171 billion and the projected cost over the period 1981 to 1990 is estimated at $525.8 billion.

In Table 2 (Air Pollution Control Costs), the groups showing the largest portions of investment costs include the Energy Industries (specifically, power plants), and Mobile Sources. The Mobile Sources costs include costs for lead phase-down and lead-free gasoline production; these elements of cost may be associated with the Petroleum Refining Industry in other studies. The Metals and Other Industrial Costs groups fall below Mobile Sources in a ranking of Investment expenditures. The estimated costs for the metals industry group shows separate costs for the three major metals: steel, aluminum, and copper.

One of the individual features which may be noted in Table 2 (Air Pollution Control Costs) is the singularly high level of expenditures for the control of Mobile Sources; these costs reflect the projected automobile populations, as well as increasing stringency of regulations.

In Table 3 (Water Pollution Control Costs), the highest level of expenditure is that for the Chemical Industries (principally the organic chemicals industry) with the next highest levels of expenditures shown for the energy industry (largely for Petroleum Refining and, again, electric power plants).

The water pollution control costs in Table 3 include federal grants for construction of municipal treatment plants as an investment expenditure. The Water Report contains a discussion of nonpoint sources (agriculture, silviculture, urban runoff and new construction runoff control) in Chapter 10. The costs for controlling pollution from nonpoint sources are discussed in Chapter 10, but do not appear in the cost tables in this summary. Estimates of these costs range from annual expenditures of $4 billion to $5 billion.

THE ECONOMIC IMPACT OF EPA'S PROGRAM

This section provides some perspective as to the economic effects of EPA programs. Widely disparate views on the economic impact of EPA's program have been expressed by some environmentalists--who say the program stimulates the economy and creates jobs--and by some businessmen--who say the program causes capital shortages and inflation in boom times and causes unemployment and stifles profitability in recessionary times.

The truth probably lies somewhere in between. While costs of pollution programs are high in absolute terms, the overall effects on prices, GNP, and employment are projected to be small and neither strongly positive nor negative in the long run.

Most concern about economic effects should be focused on a few heavily polluting industries which either are very capital-intensive materials production industries or are characterized by many economically

TABLE 1. COST OF AIR AND WATER POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

	INVESTMENT				
	1981	1970-78	1979-81	1979-84	1981-90
GOVERNMENT EXPENDITURES	6539.00	53350.98	23820.99	41628.98	59962.96
FUELS & ENERGY					
COAL MINING & COAL CLEANING	7.54	126.50	22.57	39.57	99.85
OIL & GAS EXTRACTION & PROCESSING	4.71	1300.72	9.08	25.60	141.85
PETROLEUM REFINING	220.37	3817.07	562.96	1034.32	1068.88
ELECTRIC UTILITIES	2515.07	5357.42	6035.46	13106.33	26126.81
COAL GASIFICATION	0.0	0.0	0.0	0.0	56.23
SUBTOTAL	2747.69	10601.70	6630.07	14205.81	27493.62
MOBILE SOURCES	4581.41	22803.54	13649.57	28654.07	58978.92
NONPOINT SOURCES	XXX.XX	XXX.XX	XXX.XX	XXX.XX	XXX.XX
FOOD PROCESSING					
FEEDLOTS & MEAT PROCESSING	93.12	203.99	274.97	442.30	638.48
OTHER FOOD PROCESSING	75.46	2259.47	299.62	515.38	1580.08
SUBTOTAL	168.58	2463.46	574.59	957.68	2218.56
CHEMICALS					
BASIC INORGANIC CHEMICALS	34.15	825.91	157.46	269.95	887.49
ORGANIC CHEMICALS	385.62	3724.81	1344.86	2863.33	8232.47
AGRICULTURAL CHEMICALS	64.44	490.66	195.93	346.78	697.62
FORMULATED CHEMICALS	18.10	1304.21	46.70	92.05	173.28
SUBTOTAL	502.31	6345.57	1744.95	3572.10	9990.86
CONSTRUCTION MATERIALS	60.80	1023.29	198.72	378.10	1003.15
METALS					
ORE MINING & DRESSING	0.0	455.30	212.61	212.61	0.0
IRON & STEEL	329.26	3335.91	1270.13	2917.30	3020.48
ALUMINUM	23.90	420.12	78.31	296.69	578.72
COPPER	53.90	1926.30	161.70	342.10	387.40
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	31.36	894.21	112.82	285.08	447.20
SUBTOTAL	438.42	7031.84	1835.57	4053.77	4433.80
SOFTGOODS					
PULP & PAPER	79.89	4609.65	220.40	427.75	667.17
TEXTILES	5.11	59.85	19.55	45.97	122.12
LEATHER & RUBBER	36.54	214.72	63.57	192.33	306.26
SUBTOTAL	121.53	4884.23	303.52	666.05	1095.55

MANUFACTURING					
ELECTROPLATING AND METAL FINISHING..........	0.0	0.0	0.0	662.33	785.27
SURFACE COATINGS...........................	124.70	167.78	368.86	788.30	1055.02
FURNITURE MANUFACTURE......................	0.0	29.01	0.0	0.0	0.22
LEAD ACID BATTERIES........................	0.0	21.35	0.0	0.02	15.92
SUBTOTAL................................	124.70	218.14	368.86	1450.66	1856.43
SERVICES					
DRYCLEANING................................	0.0	0.0	0.0	142.79	407.98
HOSPITALS..................................	43.39	293.07	121.63	271.47	702.54
PHOTOGRAPHIC PROCESSING....................	0.0	3.72	0.0	0.27	4.95
SUBTOTAL................................	43.39	296.79	121.63	414.53	1115.48
MUNICIPAL WASTE INCINERATION..................	5.32	71.02	38.63	58.58	57.10
OTHER INDUSTRIAL COSTS					
INDUSTRIAL & COMM. HEATING BOILERS..........	438.80	4281.55	1600.75	3751.24	7136.02
INDUSTRIAL, COMM. & BLDG. INCINERATORS......	92.83	281.09	194.10	472.58	578.08
WOOD WASTE BOILERS.........................	0.86	87.66	2.78	44.10	111.27
SUBTOTAL................................	532.50	4650.30	1797.63	4267.92	7825.37
TOTAL...................................	15865.52	113740.19	51084.59	100308.11	176029.38

TABLE 1. COST OF AIR AND WATER POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

			ANNUAL COSTS		
	1981	1970-78	1979-81	1979-84	1981-90
GOVERNMENT EXPENDITURES	16125.11	59990.33	45171.11	99207.94	197012.94
FUELS & ENERGY					
COAL MINING & COAL CLEANING	102.89	291.46	286.28	628.41	1188.99
OIL & GAS EXTRACTION & PROCESSING	576.24	1321.51	1695.20	3499.09	6317.89
PETROLEUM REFINING	1152.66	3557.36	3094.71	6869.07	12345.55
ELECTRIC UTILITIES	7760.20	22272.53	21962.40	48250.20	99131.50
COAL GASIFICATION	0.0	0.0	0.0	0.0	302.20
SUBTOTAL	9591.99	27442.84	27038.57	59246.77	119286.00
MOBILE SOURCES	6047.33	55098.61	17806.84	37792.25	80554.37
NONPOINT SOURCES	XXX.XX	XXX.XX	XXX.XX	XXX.XX	XXX.XX
FOOD PROCESSING					
FEEDLOTS & MEAT PROCESSING	181.64	225.45	435.01	1129.98	2724.99
OTHER FOOD PROCESSING	1388.89	4333.54	4127.70	8359.39	14324.20
SUBTOTAL	1570.53	4558.99	4562.70	9489.36	17049.18
CHEMICALS					
BASIC INORGANIC CHEMICALS	403.12	1077.40	1138.30	2395.65	4008.20
ORGANIC CHEMICALS	1018.59	1754.12	2820.91	6448.18	15837.15
AGRICULTURAL CHEMICALS	246.41	483.52	668.76	1532.45	3358.47
FORMULATED CHEMICALS	285.67	824.01	837.32	1722.71	2943.86
SUBTOTAL	1953.79	4139.04	5465.29	12098.96	26147.65
CONSTRUCTION MATERIALS	397.48	1270.75	1132.46	2441.35	4741.65
METALS					
ORE MINING & DRESSING	165.68	221.95	486.76	983.80	1656.81
IRON & STEEL	1596.26	4459.93	4379.04	10532.08	22222.81
ALUMINUM	199.22	698.30	570.29	1213.92	2347.64
COPPER	416.02	1844.68	1229.39	2465.64	3643.82
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	243.63	879.43	709.83	1511.27	2876.18
SUBTOTAL	2620.81	8104.27	7375.30	16706.69	32747.23
SOFTGOODS					
PULP & PAPER	1173.10	3640.21	3466.10	7085.41	11987.03
TEXTILES	26.72	60.17	74.49	167.36	355.10
LEATHER & RUBBER	66.07	163.99	175.28	448.76	1021.60
SUBTOTAL	1265.89	3864.36	3715.88	7701.52	13363.73

MANUFACTURING					
ELECTROPLATING AND METAL FINISHING..........	0.0	0.0	0.0	216.33	910.12
SURFACE COATINGS...........................	122.13	59.20	278.25	830.35	2374.98
FURNITURE MANUFACTURE......................	7.02	26.49	21.06	42.13	70.39
LEAD ACID BATTERIES........................	6.29	25.28	18.86	37.73	63.83
SUBTOTAL...................................	135.43	110.97	318.17	1126.54	3419.31
SERVICES					
DRYCLEANING................................	0.0	0.0	0.0	40.22	466.61
HOSPITALS..................................	101.67	219.91	271.94	652.98	1667.99
PHOTOGRAPHIC PROCESSING....................	1.82	4.90	5.31	11.08	21.22
SUBTOTAL...................................	103.48	224.81	277.25	704.28	2155.82
MUNICIPAL WASTE INCINERATION.................	25.62	51.21	79.29	155.17	250.13
OTHER INDUSTRIAL COSTS					
INDUSTRIAL & COMM. HEATING BOILERS..........	2499.11	5578.79	6546.61	14190.84	26056.77
INDUSTRIAL, COMM. & BLDG. INCINERATORS......	156.97	313.08	392.59	1048.09	2488.41
WOOD WASTE BOILERS.........................	47.88	171.23	140.33	292.11	541.96
SUBTOTAL...................................	2703.96	6063.11	7079.53	15531.03	29087.13
TOTAL......................................	42541.27	170917.94	120022.25	262199.57	525812.30

TABLE 2. COST OF AIR POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

	INVESTMENT				
	1981	1970-78	1979-81	1979-84	1981-90
FUELS & ENERGY					
COAL MINING & COAL CLEANING	1.77	51.62	5.14	10.81	22.80
OIL & GAS EXTRACTION & PROCESSING	4.71	9.81	9.08	25.60	70.30
PETROLEUM REFINING	113.71	666.69	298.97	499.30	691.19
ELECTRIC UTILITIES	2497.98	4758.16	6006.99	12992.43	25959.84
COAL GASIFICATION	0.0	0.0	0.0	0.0	56.23
SUBTOTAL	2618.17	5486.28	6320.17	13528.13	26800.35
MOBILE SOURCES	4581.41	22803.54	13649.57	28654.07	58978.92
FOOD PROCESSING					
OTHER FOOD PROCESSING	35.19	1009.95	187.75	300.29	912.45
SUBTOTAL	35.19	1009.95	187.75	300.29	912.45
CHEMICALS					
BASIC INORGANIC CHEMICALS	25.39	601.48	144.16	235.55	750.32
ORGANIC CHEMICALS	25.43	143.09	261.32	339.52	296.90
AGRICULTURAL CHEMICALS	7.33	172.58	37.46	64.82	239.48
FORMULATED CHEMICALS	6.36	33.63	20.44	42.48	82.99
SUBTOTAL	64.50	950.77	463.37	682.36	1369.69
CONSTRUCTION MATERIALS	44.20	669.18	143.62	279.08	827.13
METALS					
IRON & STEEL	195.00	1798.00	809.00	1980.00	2124.00
ALUMINUM	15.33	370.15	52.11	261.92	549.78
COPPER	53.90	1926.30	161.70	342.10	387.40
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	28.45	757.83	106.33	270.44	414.96
SUBTOTAL	292.68	4852.27	1129.13	2854.46	3476.14
SOFTGOODS					
PULP & PAPER	71.88	1395.56	212.40	391.73	472.76
SUBTOTAL	71.88	1395.56	212.40	391.73	472.76

MANUFACTURING					
SURFACE COATINGS	120.23	167.78	350.97	739.22	1005.24
LEAD ACID BATTERIES	0.0	21.35	0.0	0.02	15.92
SUBTOTAL	120.23	189.13	350.97	739.24	1021.16
SERVICES					
DRYCLEANING	0.0	0.0	0.0	142.79	407.98
SUBTOTAL	0.0	0.0	0.0	142.79	407.98
MUNICIPAL WASTE INCINERATION	5.32	71.02	38.63	58.58	57.10
OTHER INDUSTRIAL COSTS					
INDUSTRIAL & COMM. HEATING BOILERS	438.80	4281.55	1600.75	3751.24	7136.02
INDUSTRIAL, COMM. & BLDG. INCINERATORS	92.83	281.09	194.10	472.58	578.08
WOOD WASTE BOILERS	0.86	87.66	2.78	44.10	111.27
SUBTOTAL	532.50	4650.30	1797.63	4267.92	7825.37
TOTAL	8366.03	42077.94	24293.18	51898.59	102147.94

TABLE 2. COST OF AIR POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

	ANNUAL COSTS				
	1981	1970-78	1979-81	1979-84	1981-90
GOVERNMENT EXPENDITURES	606.00	7117.98	2208.00	3807.00	5264.99
FUELS & ENERGY					
COAL MINING & COAL CLEANING	16.97	66.74	48.07	105.10	178.10
OIL & GAS EXTRACTION & PROCESSING	5.27	10.83	11.97	36.73	132.27
PETROLEUM REFINING	168.83	468.72	435.55	1018.55	2041.50
ELECTRIC UTILITIES	7452.62	20941.11	21060.46	46351.02	95678.69
COAL GASIFICATION	0.0	0.0	0.0	0.0	302.20
SUBTOTAL	7643.69	21487.39	21556.04	47511.39	98332.62
MOBILE SOURCES	6047.33	55098.61	17806.84	37792.25	80554.37
FOOD PROCESSING					
OTHER FOOD PROCESSING	151.74	474.16	437.67	916.22	1683.05
SUBTOTAL	151.74	474.16	437.67	916.22	1683.05
CHEMICALS					
BASIC INORGANIC CHEMICALS	311.69	804.15	875.63	1836.79	2974.95
ORGANIC CHEMICALS	108.23	60.40	299.77	666.98	1385.55
AGRICULTURAL CHEMICALS	56.44	157.67	165.93	342.99	629.99
FORMULATED CHEMICALS	27.68	59.81	73.36	168.29	356.37
SUBTOTAL	504.04	1082.02	1414.70	3015.06	5346.85
CONSTRUCTION MATERIALS	294.39	1008.45	838.46	1811.59	3543.11
METALS					
IRON & STEEL	1212.75	3512.26	3353.98	8128.00	17330.83
ALUMINUM	169.91	644.39	492.55	1038.28	1970.94
COPPER	416.02	1844.68	1229.39	2465.64	3643.82
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	200.37	749.62	583.28	1245.99	2388.38
SUBTOTAL	1999.05	6750.93	5659.20	12877.90	25333.94
SOFTGOODS					
PULP & PAPER	362.84	1057.81	1038.79	2217.21	3891.47
SUBTOTAL	362.84	1057.81	1038.79	2217.21	3891.47

MANUFACTURING					
SURFACE COATINGS	115.49	59.20	265.99	776.24	2209.04
LEAD ACID BATTERIES	6.29	25.28	18.86	37.73	63.83
SUBTOTAL	121.78	84.48	284.84	813.97	2272.88
SERVICES					
DRYCLEANING	0.0	0.0	0.0	40.22	466.61
SUBTOTAL	0.0	0.0	0.0	40.22	466.61
MUNICIPAL WASTE INCINERATION	25.62	51.21	79.29	155.17	250.13
OTHER INDUSTRIAL COSTS					
INDUSTRIAL & COMM. HEATING BOILERS	2499.11	5578.79	6546.61	14190.84	26056.77
INDUSTRIAL, COMM. & BLDG. INCINERATORS	156.97	313.08	392.59	1048.09	2488.41
WOOD WASTE BOILERS	47.88	171.23	140.33	292.11	541.96
SUBTOTAL	2703.96	6063.11	7079.53	15531.03	29087.13
TOTAL	20460.37	100275.12	58403.30	126487.87	256025.75

TABLE 3. COST OF WATER POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

	INVESTMENT				
	1981	1970-78	1979-81	1979-84	1981-90
GOVERNMENT EXPENDITURES	6539.00	53350.98	23820.99	41628.98	59962.96
FUELS & ENERGY					
COAL MINING & COAL CLEANING	5.77	74.88	17.44	28.76	77.05
OIL & GAS EXTRACTION & PROCESSING	0.0	1290.90	0.0	0.0	71.56
PETROLEUM REFINING	106.66	3150.38	264.00	535.03	377.69
ELECTRIC UTILITIES	17.08	599.26	28.47	113.90	166.98
SUBTOTAL	129.52	5115.42	309.91	677.68	693.27
NONPOINT SOURCES	XXX.XX	XXX.XX	XXX.XX	XXX.XX	XXX.XX
FOOD PROCESSING					
FEEDLOTS & MEAT PROCESSING	93.12	203.99	274.97	442.30	638.48
OTHER FOOD PROCESSING	40.27	1249.52	111.87	215.09	667.63
SUBTOTAL	133.39	1453.51	386.83	657.39	1306.11
CHEMICALS					
BASIC INORGANIC CHEMICALS	8.76	224.44	13.30	34.41	137.18
ORGANIC CHEMICALS	360.20	3581.72	1083.54	2523.81	7935.58
AGRICULTURAL CHEMICALS	57.11	318.08	158.47	281.96	458.14
FORMULATED CHEMICALS	11.75	1270.58	26.26	49.57	90.29
SUBTOTAL	437.81	5394.80	1281.58	2889.74	8621.18
CONSTRUCTION MATERIALS	16.60	354.11	55.10	99.02	176.02
METALS					
ORE MINING & DRESSING	0.0	455.30	212.61	212.61	0.0
IRON & STEEL	134.26	1537.91	461.13	937.30	896.48
ALUMINUM	8.57	49.97	26.20	34.77	28.94
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	2.91	136.38	6.49	14.63	32.24
SUBTOTAL	145.73	2179.57	706.44	1199.31	957.66
SOFTGOODS					
PULP & PAPER	8.01	3214.10	8.01	36.02	194.41
TEXTILES	5.11	59.85	19.55	45.97	122.12
LEATHER & RUBBER	36.54	214.72	63.57	192.33	306.26
SUBTOTAL	49.65	3488.67	91.12	274.32	622.79

MANUFACTURING					
ELECTROPLATING AND METAL FINISHING..........	0.0	0.0	0.0	662.33	785.27
SURFACE COATINGS............................	4.47	0.0	17.89	49.08	49.78
FURNITURE MANUFACTURE.......................	0.0	29.01	0.0	0.0	0.22
SUBTOTAL................................	4.47	29.01	17.89	711.42	835.27
SERVICES					
HOSPITALS...................................	43.39	293.07	121.63	271.47	702.54
PHOTOGRAPHIC PROCESSING.....................	0.0	3.72	0.0	0.27	4.95
SUBTOTAL................................	43.39	296.79	121.63	271.74	707.50
TOTAL...................................	7499.49	71662.25	26791.41	48409.53	73881.44

TABLE 3. COST OF WATER POLLUTION CONTROL
(IN MILLIONS OF 1981 DOLLARS)

	ANNUAL COSTS				
	1981	1970-78	1979-81	1979-84	1981-90
GOVERNMENT EXPENDITURES	15519.12	52872.34	42963.11	95401.00	191748.00
FUELS & ENERGY					
COAL MINING & COAL CLEANING	85.92	224.72	238.21	523.31	1010.89
OIL & GAS EXTRACTION & PROCESSING	570.97	1310.68	1683.23	3462.36	6185.62
PETROLEUM REFINING	983.83	3088.64	2659.16	5850.52	10304.06
ELECTRIC UTILITIES	307.58	1331.42	901.95	1899.18	3452.85
SUBTOTAL	1948.30	5955.45	5482.53	11735.38	20953.41
NONPOINT SOURCES	XXX.XX	XXX.XX	XXX.XX	XXX.XX	XXX.XX
FOOD PROCESSING					
FEEDLOTS & MEAT PROCESSING	181.64	225.45	435.01	1129.98	2724.99
OTHER FOOD PROCESSING	1237.15	3859.39	3690.03	7443.17	12641.16
SUBTOTAL	1418.79	4084.83	4125.04	8573.14	15366.14
CHEMICALS					
BASIC INORGANIC CHEMICALS	91.43	273.25	262.67	558.85	1033.25
ORGANIC CHEMICALS	910.36	1693.72	2521.14	5781.20	14451.60
AGRICULTURAL CHEMICALS	189.98	325.85	502.83	1189.46	2728.48
FORMULATED CHEMICALS	257.98	764.20	763.96	1554.42	2587.49
SUBTOTAL	1449.75	3057.02	4050.60	9083.91	20800.80
CONSTRUCTION MATERIALS	103.09	262.30	294.00	629.75	1198.54
METALS					
ORE MINING & DRESSING	165.68	221.95	486.76	983.80	1656.81
IRON & STEEL	383.51	947.67	1025.06	2404.08	4891.98
ALUMINUM	29.31	53.91	77.74	175.64	376.70
NONFERROUS METALS,FERROALLOYS,& FOUNDRIES	43.26	129.82	126.55	265.28	487.80
SUBTOTAL	621.76	1353.34	1716.10	3828.80	7413.29
SOFTGOODS					
PULP & PAPER	810.26	2582.40	2427.31	4868.21	8095.56
TEXTILES	26.72	60.17	74.49	167.36	355.10
LEATHER & RUBBER	66.07	163.99	175.28	448.76	1021.60
SUBTOTAL	903.05	2806.55	2677.09	5484.32	9472.26

MANUFACTURING					
ELECTROPLATING AND METAL FINISHING	0.0	0.0	0.0	216.33	910.12
SURFACE COATINGS	6.63	0.0	12.26	54.12	165.93
FURNITURE MANUFACTURE	7.02	26.49	21.06	42.13	70.39
SUBTOTAL	13.65	26.49	33.32	312.57	1146.44
SERVICES					
HOSPITALS	101.67	219.91	271.94	652.98	1667.99
PHOTOGRAPHIC PROCESSING	1.82	4.90	5.31	11.08	21.22
SUBTOTAL	103.48	224.81	277.25	664.06	1689.22
TOTAL	22080.91	70642.81	61618.96	135711.69	269786.55

marginal operations. Of key importance for these industries are (1) concerns about limits on expansion due to capital shortfalls or siting constraints posed by environmental regulations and (2) the effects of these limits on growth in these and related industries.

This section does not discuss whether environmental programs (or various elements of them) have favorable benefit/cost ratios, since few credible benefits data have been generated which would allow such analysis. This section does briefly detail what is and is not known about the costs, macroeconomic and microeconomic impacts, and energy impacts associated with the environmental program.

Costs

The federal pollution control program is projected to cost about $526 billion in the period 1981-1990 above expenditure levels which would have resulted without new federal requirements put in place since 1970. About $256 billion of these expenditures are for air pollution control, and $270 billion are for water pollution control. Capital investment for federally-required controls will be about $176 billion over the same period. About $102 billion of this total, or 58 percent, is related to the requirements of the Clean Air Act; the remaining $74 billion is for water pollution control. The cost of controlling pollution from nonpoint sources is not included in the summary tables, but is discussed in Chapter 10 of the water report. Projections for the cost of controlling nonpoint source pollution range from $4 billion to $5 billion, annually.

The annualized cost of air and water pollution control due to federal regulations was estimated at 262.2 billion for the period 1979-1984. Air pollution control costs for this period are $126.5 billion, while water pollution control costs are $135.7 billion. Capital investment costs for the same period are $100.3 billion for both air and water pollution control.

Macroeconomic Impacts

These costs can be put in perspective by looking at their macroeconomic effect on the economy. The magnitudes of these effects depend upon the general state of the economy. In a slack economy pollution control investment can stimulate growth and employment with little real effect on prices, while in a tight economy such investment can increase prices and tend to replace other capital spending plans with a relatively small effect on employment. Macroeconomic forecasts can project these effects, but only with a wide band of uncertainty.

Price and Growth Effects

A Data Resources, Inc. (DRI) forecast prepared for EPA and CEQ in July 1981 shows the Consumer Price Index is currently about 3.3 percent higher than it would have been without federal pollution requirements and that by 1987 this difference will be about 6.6 percent, meaning that consumer prices will increase an average 0.4 percentage points per year more than they would without these requirements over the period 1970-1987.

DRI estimated that real GNP in 1981 (with federal pollution regulations) is marginally lower than it would have been without federal pollution requirements because capital and other resources have been consumed that would otherwise not have been utilized. DRI estimated that by 1987 real GNP will be almost 0.7 percent lower than it would have been without federal pollution requirements.

These estimated effects on the economy are in terms of conventional measures for these prices and GNP. Since these measures do not take into account the benefits of the environmental programs in terms of improved public health and welfare, these forecasts exaggerate the negative impacts on inflation and economic growth.

Employment Effects

The DRI forecast for EPA and CEQ estimated that the impact on unemployment in 1981 would be a net decrease in the unemployment rate of 0.3 percentage points. Equipment installation and monitoring of pollution control equipment creates jobs. By 1987, the model predicts there are 524,000 additional jobs created as a result of pollution control regulations. The program directly creates jobs in the construction industry (42,000 on-site jobs on EPA-funded sewage treatment projects in 1980, with one and one-half times that number of off-site jobs) and in the pollution control manufacturing industry (Arthur D. Little, Inc., estimated that employment in this industry would be around 44,000 in 1983 as a result of the 1970 and 1972 air and water legislation), with many more indirect jobs stimulated by these expenditures.

On the other hand, when pollution control costs result in higher prices, lower demand and hence lower production and lower employment result. Furthermore, some transitional unemployment results from the closing of marginal plants which cannot afford to comply with environmental requirements. Since January 1971, 155 closures involving nearly 33,000 jobs have occurred for which the firm has said that pollution requirements were a significant factor; 53 closures involved federal action.

COST METHODOLOGY

Cost estimates for each industry are presented in a table following the corresponding chapter text. To estimate compliance costs the industry is usually divided into a number of sectors. Sectors may be defined according to production process, control technology, regulations, available cost data, or any other factors that can influence costs. The cost data for an individual sector may take one of two forms: "exogenous" total costs, or cost functions. The cost methodology section in each chapter indicates the type of cost data used in that chapter.

Exogenous sector costs are total year-by-year investment and/or O&M costs that are estimated without using the computer model designed for the report. The exogenous form is sometimes used because the complexity of the chapter precludes the use of cost functions alone. In other instances, these costs are taken from a detailed economic study of the industry commissioned by the EPA. The use of these studies improves the consistency and coherency of this report with other EPA publications. Some of these economic reports may not provide detailed information about control costs. In these cases the reported costs do not necessarily conform to the standard format, e.g., new plant costs may not be separately identified, although costs projected into the future include costs for both new and existing plants. Similarly, the source document may not use the same breakdown of annual costs or the same discount rate as is normally used in the existing computer model. Nevertheless, the overall costs and timing of the costs are reported as developed in the designated source document.

Costs in most chapter sectors are generated from cost equations that express control costs as a function of plant capacity. (Larger plants usually benefit from economies of scale.) In most cases future cost estimates are based on the assumption of continued application of current technologies. Capital and operating and maintenance (O&M) costs are calculated separately. The computer program computes total industry costs by applying the cost functions to industry plant data, taking into account compliance schedules estimated by the chapter author. The cost functions, which are based on engineering model plant costs, are expressed in a standard exponential form: $\text{Cost} = AX^B$, where X is a measure of capacity. O&M costs are adjusted according to estimates of capacity utilization percentages.

Industry plant data include the plant population for a base year, historical growth rates, and expected future growth rates. Compliance schedules simply reflect the percentage of the plant population that complied with a regulation in each past year and estimates of the percentage that will comply in each future year. These estimates are based on the compliance date specified in the pertinent regulation, allowing for lead time required to construct and install the control technology required. New plants are assumed to comply upon construction.

To calculate the annual capital costs, the computer program uses the stated life of the control equipment and a real (not nominal), before-tax discount rate of ten percent. The discount rate accounts for the "opportunity" cost of control equipment investment funds. It is understood that other systems of depreciation are used, that other discount rates are sometimes applicable, that "opportunity costs" for other uses of capital are not taken into account, and that tax write-offs are commonly applied to control equipment. The ten percent real rate is used as a "compromise" value which is intended to reflect an average value of the highly varied individual cases.

The computer program also calculates the cost of replacing control equipment at the end of its useful life. These costs are assumed to be some fraction of the original cost of equipment as certain elements, such as the foundations, do not need to be replaced.

The program excludes costs associated with pollution control that would have been incurred without the inducement of federal regulations. It does this by excluding from the plant population a precompliance fraction that is provided by the chapter author. This fraction represents plants that either can comply with the applicable regulation without installing controls or plants that installed controls even in the absence of regulations.

When pollution control results in product or by-product recovery, the value of the recovered product is calculated and credited against the O&M costs associated with the control. Credits are estimated by multiplying the price of the recovered product by the amount of the recovered product. In some cost sectors, the O&M costs or cost function have been estimated net of credits. In other cases, credits or credit functions have been estimated separately. In credit function sectors, credits, like costs, are expressed as an exponential function: Credit = AX^B, where X is a measure of capacity. Credits, in the same way as O&M costs, are adjusted according to capacity utilization estimates.

Most cost estimates presented in this report are based on the cost of installing and operating controls to meet standards at each regulated source. Thus, they do not reflect less costly control strategies available for some facilities either through creation of emission bubbles or by trading emission reduction credits with other facilities.

This report also does not reflect any actions taken by industrial plants to decrease overall wastewater discharge after promulgation of regulations. Because data collected by the Bureau of Census indicate that the amount of water discharged by industry is decreasing, the cost estimates in this report may be overstated.

This cost methodology differs from that followed in the August, 1979 report in that it:

1. includes estimates of replacement costs, and
2. does not assume that any fraction of industry was controlling emissions to the level set by New Source Performance Standards before the promulgation of these standards.

Two other areas of costs are reported here which are not developed through the methodology describe above. Costs to government are reported based on expenditures as scheduled in legislation. The procedure for estimating the costs of control for mobile sources (automobiles, aircraft, etc.) is described within the text of Chapter A4.

The uncertainties of forecasting even five years into the future are well known. The estimates are based mainly on present technology and current trends in industry growth, with no allowance for innovation. In some situations, control technology has been assumed to be available that has not yet been commercially demonstrated. The estimated costs are derived from an extrapolation of current practice; rarely in this century would such an extrapolation have held true.

OTHER METHODOLOGIES

Various other sources have estimated the cost of pollution control using other techniques. This section discusses some of these other sources and how they differ form this report.

Bureau of Economic Analysis

The Bureau of Economic Analysis (BEA), U.S. Department of Commerce, publishes the results of an annual survey of industries detailing capital expenditures for air, water, and solid waste pollution abatement. The survey requests information on total plant and equipment expenditures for pollution abatement, not just that attributable to federal legislation.

One of the major features of the BEA survey is that it samples enterprises, not actual plants. A company is categorized by its major product. For example, if a large petroleum company owns a textile mill, any pollution control investment at the textile mill would be classified under petroleum refining. Thus, while the aggregate BEA estimates are quite useful, the individual industry-specific estimates reveal little about the cost to a specific industrial process.

Bureau of the Census

The Bureau of the Census, U.S. Department of Commerce, publishes the results of an annual survey of manufacturing establishments detailing both capital investment and operating costs for pollution abatement. This survey also asks for total expenditures, not just that due to federal regulation. Unlike BEA, the Census survey is based on a plant or establishment classification. Therefore, industry-specific estimates reveal more about the cost to a specific industrial process. The Census survey, however, includes manufacturing industries only.

One of the main problems with the Census survey is that depreciation is included as a part of operating costs. Only total operating costs are reported by program (air, water, or solid waste). The specific line items of operating costs (i.e., labor, materials and depreciation) are not reported by media.

Since the depreciable lives of air and water pollution abatement equipment vary considerably, it is impossible to accurately subtract out depreciation. Furthermore, the depreciation expenses are likely to reflect changes in tax provisions. Thus, the inclusion of depreciation limits the reliability of this survey in estimating operating and maintenance costs.

McGraw-Hill Survey

The Economics Department of McGraw-Hill Publications Company issues the results of an annual survey of pollution control expenditures. The methodology used for this survey has never been revealed by the Company, and, thus, it is difficult to compare with other estimates.

Key to aggregated cost tables in executive summary

Table entries	"Air" report chapter number	"Water" report chapter numbers
Government Expenditures	A2.	W2.
Fuels & Energy		
Coal Mining & Coal Cleaning	A3.5	W3.1
Oil & Gas Extraction & Processing	A3.3	W3.2
Petroleum Refining	A3.4	W3.3
Electric Utilities	A3.1	W3.4
Coal Gasification	A3.6	-
Mobile Sources	A4	-
Nonpoint Sources	-	W10.
Food Processing		
Feedlots and Meat Processing	-	W8.6, W8.7
Other Food Processing	A9.3, A9.4	W8.1, W8.2, W8.3, W8.4, W8.5
Chemicals		
Basic Inorganic Chemicals	A5.4, A5.7, A5.8	W4.2
Organic Chemicals	A5.1, A5.2	W4.1, W4.3
Agricultural Chemicals	A5.3, A5.5, A5.6, A5.9	W4.8, W4.9, W4.10
Formulated Chemicals	A8.1, A8.4, A8.5	W4.5, W4.6, W4.7, W4.11, W4.12, W7.3, W9.1
Construction Materials	A7.1, A7.2, A7.3, A7.4, A7.5, A9.5	W6.1, W6.2, W6.3, W6.4, W6.5, W6.6. W7.1
Metals		
Ore Mining & Dressing	-	W5.1
Iron & Steel	A6.1	W5.2
Aluminum	A6.5	W5.5
Copper	A6.6	-
Nonferrous Metals, Ferroalloys, & Foundries	A6.2, A6.3, A6.4, A6.7, A6.8, A6.9, A6.10. A6.11. A6.12	W5.3, W5.4, W5.6
Soft Goods		
Pulp & Paper	A9.1, A9.2	W7.4
Textiles	-	W4.14
Leather & Rubber	-	W4.4, W8.3
Manufacturing		
Electroplating	-	W5.7
Surface Coatings	A8.2	W5.8, W5.9
Furniture Manufacture	-	W7.2
Lead Acid Batteries	A8.6	-
Services		
Drycleaning	A8.3	-
Hospitals	-	W9.2
Photographic Processing	-	W4.13
Municipal Waste Incineration	A10.1	-
Other Industrial Costs		
Industrial & Commercial Heating Boilers	A3.2	-
Industrial & Commercial Incinerators	A10.2	-
Wood Waste Boilers	A3.7	-

THE COST OF CLEAN AIR

REPORT OF THE ADMINISTRATOR
OF THE
ENVIRONMENTAL PROTECTION AGENCY
TO THE
CONGRESS OF THE UNITED STATES
IN COMPLIANCE WITH
SECTION 321(c) OF THE CLEAN AIR ACT, AS AMENDED BY PUBLIC LAW 91-604, THE CLEAN AIR AMENDMENTS OF 1970

A1-1

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A6.5	Primary Aluminum Smelting	A6.5-1
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A6.7	Primary Lead	A6.7-1
A6.8	Primary Zinc Smelting Industry	A6.8-1
A6.9	Secondary Aluminum	A6.9-1
A6.10	Brass and Bronze Industry	A6.10-1
A6.11	Secondary Lead Smelting	A6.11-1
A6.12	Secondary Zinc	A6.12-1
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Chapter A1 Introduction and Summary

Section 312(a) of the Clean Air Act ("the Act" or CAA) requires that the Administrator of the Environmental Protection Agency (EPA) submit to Congress a detailed summary of the costs incurred to comply with the Act. The Cost of Clean Air Report is written in fulfillment of that requirement. The report provides air pollution control cost estimates for each industry (or other source category) that incurs high control costs and/or produces exceptionally high uncontrolled emissions levels.

This report includes only those costs incurred to meet federally mandated regulations. It does not include all costs of abating air pollution. Costs are based on federal regulations and regulations established by the states in implementation plans submitted to EPA. The cost estimates are intended to be incremental costs, meaning that they exclude costs for the estimated level of control practiced prior to the 1970 Clean Air Act Amendments.

All abatement costs in this report are stated in January 1981 dollars. Where costs are derived relative to another time period, these costs were inflated using the implicit price deflator of the Gross National Product (fixed nonresidential part).

Table A1.3 (located at the end of the chapter) summarizes estimates of the capital investments and annualized costs required for implementing the Act in 1981 and over the periods 1970-1978, 1979-1981, 1979-1984, and 1981-1990. Annualized costs include operating and maintenance costs, deposition, and interest charges. Each figure in Table A1.3 is repeated in the appropriate industry chapter, where important assumptions and background data are presented and discussed.

The chapter corresponding to each industry is divided into five sections: Industry Characteristics, Emission Sources and Pollutants, Regulations, Control Technology, and Cost Methodology. Appendices for each of the individual chapters are grouped together in a separate volume. The appendices contain more detailed cost information, descriptions of regulations, industry data, assumptions, and references. A comprehensive reference list also appears at the end of this volume. The purpose of this report is to estimate and summarize air pollution control costs for a very broad range of industries. The report is not intended to provide detailed discussions of production processes and the complete range of applicable control techniques. Interested readers are encouraged to consult the references for more complete technical descriptions and evaluations.

Note that this report does not dictate EPA policy with respect to the application of presently available or projected technology for the control of effluent quality by any industry or activity. Simplifying assumptions were required in order to estimate the effect of EPA Regulations on the industries included. The control technologies, or mix thereof, which were assumed in order to provide these estimates are neither specifically required by law nor by EPA; no contrary interpretation of the contents of this document should be made.

The remainder of this introduction is presented in three sections. The first section provides an overview of federal air pollution control requirements and regulations. The second section briefly describes several widely used air pollution control technologies. The third section describes the methodology used in this report to estimate air pollution control costs. These discussions are presented in this introduction to avoid excessive repetition within the main body of the report. A thorough reading of these sections will enhance the reader's understanding of the individual chapters.

Federal Air Regulations

The 1970 and 1977 Clean Air Act Amendments required EPA to establish national ambient air quality standards (NAAQS). The Amendments created two primary programs for meeting these standards. One program focuses on mobile source emissions. Most mobile source regulations are in the form of limitations on the allowable emission rates of mobile sources, such as automobiles, trucks, aircraft, and motorcycles. Responsibility for compliance with mobile source standards is primarily borne by vehicle manufacturers. These standards are described in greater detail in Chapter 4.

The second program for meeting NAAQS involves the control of stationary source emissions. Stationary source regulations are implemented through the states. The remainder of this section explains the major components of the stationary source control program.

Each state is divided into several areas. These areas are identified either as in attainment or nonattainment of the air quality standards for each of six criteria pollutants: particulate matter, sulfur oxides (sulfur dioxide), nitrogen oxides, carbon monoxide, ozone (photochemical oxidants), and lead (40 CFR 52). The Act requires that each state adopt a State Implementation Plan (SIP) to ensure eventual attainment and maintenance of air quality standards for nonattainment areas and to maintain an adequate level of air quality in attainment areas (CAA, Section 110; 40 CFR 51). SIPs must be approved by EPA, after which they are incorporated into the Code of Federal Regulations (40 CFR 52). Each SIP contains provisions for meeting federal requirements (i.e., requirements specified in the Act) and requirements set by the individual state. 1/ In

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1/ When setting stationary source standards to achieve NAAQS for the criteria pollutants, states take into account the reduction in emissions expected to be achieved through the federal mobile source standards. SIPs must also include under certain conditions, programs for inspection and testing of in-use motor vehicles, known as an inspection/maintenance (I/M) program [CAA, Section 110(a)(2)(G); 40 CFR 51.11(b)]. Because emission levels are lowered as a result of the mobile source controls, states may regulate stationary sources to a lesser degree than might be the case without the mobile source standards.

cases where federal and state emission regulations would govern the same source, the more stringent of the two generally applies.

The federal air quality control programs, which are incorporated into the SIPs, generally distinguish between existing and new sources and between attainment and nonattainment areas. The programs include the following regulations exclusively for new or modified sources: New Source Performance Standards (NSPS) for sources in all areas; Prevention of Significant Deterioration (PSD) regulations, which require Best Available Control Technology (BACT) for sources in attainment areas; and requirements that sources in nonattainment areas meet Lowest Achievable Emissions Rates (LAER). The federal programs also include National Emission Standards for Hazardous Air Pollutants (NESHAP) for new and existing sources in all areas, and visibility regulations, which require Best Available Retrofit Technology (BART) for certain existing sources in designated attainment areas.

The following discussion first provides a general description of the SIPs and their state-specific regulations. It then more completely describes the federal air programs listed above. The section concludes with an explanation of the regulations costed in this report.

State-Specific Regulations in SIPs

A State Implementation Plan must specify a control strategy for each major source located in, or impacting on, a nonattainment area. This strategy must be calculated to result in the area's reaching and maintaining NAAQS for each pollutant. More general state regulations, which are also incorporated into the SIPs, apply to sources in attainment and unclassified areas. 1/ The following discussion focuses on the state-specific standards, not the federal programs discussed in the next section.

SIPs were originally required to establish emission limits for five criteria pollutants: particulate matter, sulfur oxides, nitrogen oxides, carbon monoxide, and ozone. 2/ Lead was added as a criteria pollutant in 1978. 3/ The process of determining lead attainment status and developing lead emission standards is still underway.

1/ Some areas are not classified as attainment or nonattainment areas because of inadequate monitoring facilities.

2/ Hydrocarbons, precursors of ozone, were initially a criteria pollutant. Because "no consistent quantitative relationship exists nationwide between ambient air ozone concentrations and hydrocarbon air quality levels," EPA revoked the NAAQS for hydrocarbons on January 5, 1983 (48 FR 627).

3/ October 5, 1978 (43 FR 46270)

In addition to the control of criteria pollutants, the 1977 Amendments [CAA, Section 111(d)] required SIPs to establish limits for "designated pollutants" that are emitted from "designated facilities." A pollutant becomes a designated pollutant if it is not a criteria pollutant and its emissions are subject to a NSPS. The NSPS specifies the type of facility that emits the designated pollutant. Such facility, if already existing, is a designated facility. Requiring states to establish standards for designated pollutant emissions from existing designated facilities (40 CFR 60.21) effectively broadens the applicable NSPS to cover existing facilities. However, the standards for existing facilities are not necessarily as stringent as the NSPS. Designated pollutants/facilities include total reduced sulfur (TRS) from Kraft pulp mills, fluorides from phosphate fertilizer plants, and acid mist from sulfuric acid plants.

An industry whose production processes emit several pollutants may be subject to differing emission limits for each pollutant, depending on the classification of its location. For example, the area in which a plant is located may be classified as attainment for particulates but nonattainment for sulfur oxides. The cost of meeting emission limits will depend on the attainment status of the source location and the stringency of the state's regulatory program.

EPA encourages states to set nonattainment area emission limitations that require Reasonably Available Control Technology (RACT) (CAA, Section 108) for existing major sources. The Agency provides guidance to states in defining RACT for specific pollution-emitting processes. This guidance includes suggested process weight rate standards for general process industries and industry-specific emission limits and control techniques (40 CFR 51, Appendix B). EPA also provides guidance on RACT in a series of source-specific control technique guideline documents. If less stringent limits will result in attaining air quality standards in a timely manner, states may avoid requiring RACT levels of control.

States also have significant flexibility in choosing the standards applied in attainment areas. Thus, there may be a great deal of state-to-state variation in the degree of air pollution control required for an existing emission source whether that source is a nonattainment area or an attainment area. Some states establish general emission limits that apply to a large group of industries emitting that pollutant; others define limits for specific industries. States may specify standards for each emission source in a nonattainment area. In these cases, standards for similar emission sources may vary from one nonattainment area to another within the same state.

The Code of Federal Regulations defines the existing point sources in nonattainment areas that are subject to SIPs. These include stationary sources that emit over 100 tons per year of any pollutant in an urban area, those that emit over 25 tons per year of any pollutant in a non-urban area, and any stationary source listed in Appendix C of Title 40, Section 51, of the Code of Federal Regulations (40 CFR 51, Appendix C). 1/ This latter category includes certain types of chemical process industries, food and agricultural industries, metallurgical industries, and mineral products industries.

Federal Programs For New or Modified Sources

States are responsible for implementing federal standards for new or modified sources 2/ through construction permit programs. Three categories of standards may be applied to new sources, depending on the type, size, and location of the source: New Source Performance Standards (NSPS), requirements for Best Available Control Technology (BACT), and Lowest Achievable Emissions Rate (LAER) standards. Each will be discussed separately below.

EPA has established New Source Performance Standards (NSPS) for more than 30 stationary source categories (CAA, Section III; 40 CFR 60). Table A1.1 lists the sources covered by NSPS that had been promulgated as of February 1983. An NSPS governs all new sources in the particular source category and size range specified by the standard unless BACT or LAER apply to these sources.

BACT and LAER requirements govern emissions from certain new sources in attainment and nonattainment areas, respectively. Certain categories of new sources in attainment areas are subject to prevention of significant deterioration (PSD) preconstruction review, which requires the use of Best Available Control Technology (BACT) (CAA, Part C; 40 CFR 51.24). Major new sources in nonattainment areas must control emissions to the Lowest Achievable Emissions Rate (LAER) (CAA, Section 173; 40 CFR 51.18). The major features of these permit programs are described below.

Attainment Areas: The goal of the PSD program is to prevent the deterioration of air quality in areas where emission levels are below the national ambient air quality standards (i.e., attainment areas). Emissions in each attainment area may be allowed to increase only in specified increments above the baseline concentration of a pollutant. 3/ PSD

1/ The complete definition can be found in 40 CFR 51.1. An urban area is a region with a 1970 urban place population equal to or greater than one million.

2/ In the remaining discussion new sources will also include modifications of existing sources.

3/ The PSD regulations set certain requirements for classifying an attainment area as Class I, II, or III for purposes of specifying allowable increments. For example, national parks and wilderness areas over a certain size must be designated as Class I areas. Baseline concentration is the ambient concentration within a given area measured after August 7, 1977. Increments are measured in micrograms per cubic meter and vary in stringency for each class. The allowable increment is the smallest for Class I areas and the largest for Class III areas. Allowable increments currently exist only for sulfur dioxide and total suspended particulates.

Table A1.1. New source performance standards*

Affected source	Date of initial promulgation
Fossil Fuel-Fired Steam Generators ($\geq$ 250 million Btu and for which construction is commenced after August 17, 1971)	12/23/71
Electric Utility Steam Generating Units (> 250 million Btu and for which construction is commenced after September 18, 1978)	6/11/79
Incinerators	12/23/71
Portland Cement Plants	12/23/71
Nitric Acid Plants	12/23/71
Sulfuric Acid Plants	12/23/71
Asphalt Concrete Plants	3/08/74
Petroleum Refineries	3/08/74
Storage Vessels for Petroleum Liquids (constructed after June 11, 1973 and prior to May 19, 1978)	3/08/74
Storage Vessels for Petroleum Liquids (constructed after May 18, 1978)	4/04/80
Secondary Lead Smelters	3/08/74
Secondary Brass and Bronze Ingot Production Plants	3/08/74
Iron and Steel Plants: Basic Oxygen Process Furnaces	3/08/74
Sewage Treatment Plants	3/08/74
Primary Copper Smelters	1/15/76
Primary Zinc Smelters	1/15/76
Primary Lead Smelters	1/15/76
Primary Aluminum Reduction Plants	1/26/76
Phosphate Fertilizer Industry: Wet Process Phosphoric Acid Plants	8/06/75
Phosphate Fertilizer Industry: Superphosphoric Acid Plants	8/06/75
Phosphate Fertilizer Industry: Diammonium Phosphate Plants	8/06/75
Phosphate Fertilizer Industry: Triple Superphosphate Plants	8/06/75
Phosphate Fertilizer Industry: Granular Triple Superphosphate Storage Facilities	8/06/75
Coal Preparation Plants	1/15/76
Ferroalloy Production Facilities	5/04/76
Steel Plants: Electric Arc Furnaces	9/23/75

Continued....

Table A1.1. (Continued)

Affected source	Date of initial promulgation
Kraft Pulp Mills	2/23/78
Glass Manufacturing Plants	10/07/80
Grain Elevators	8/03/78
Stationary Gas Turbines	9/10/79
Lime Manufacturing Plants	3/07/78
Automobile and Light Duty Truck Surface Coating Operations	12/24/80
Ammonium Sulfate Manufacture	11/12/80
Lead Acid Battery Manufacture	4/16/82
Phosphate Rock Plants	4/16/82
Asphalt Processing and Roofing Manufacture	8/06/82
Industrial Surface Coating: Large Appliances	10/27/82
Surface Coating of Metal Furniture	10/29/82
Metal Coil Surface Coating Operations	11/01/82
Graphic Arts Industry: Publication Rotogravure Printing	11/08/82

*Ordered as in the Code of Federal Regulations (40 CFR 60).

preconstruction review requires analysis of air quality impacts that will result from the operation of the new source. The specific Best Available Control Technology (BACT) required for a new source is determined on a case-by-case basis, depending on the air quality impact analysis, technological considerations, and the cost and energy requirements of alternative control techniques. Emission levels achievable with BACT must be at least as stringent as any applicable NSPS or NESHAP (described below). If a source is not covered by NSPS, BACT standards may be based on emission limits specified in SIP regulations for similar sources.

PSD review governs only certain sizes and/or categories of new sources. The program covers any new source that has the potential to emit at least 250 tons per year of any pollutant regulated under the Act. It also covers new sources in 28 specified categories when the new source has the potential to emit at least 100 tons per year of any pollutant. The 28 specified categories are listed in Table A1.2. BACT does not apply to any source emitting less than 100 tons per year of a pollutant or to a source that emits between 100 and 250 tons per year of a pollutant if it is not in a category listed in Table A1.2.

Nonattainment Areas: The permit program for construction of new major sources in nonattainment areas requires that any emissions from the new source not interfere with progress toward eventual attainment of national ambient air quality standards. States must ensure that additional emissions from a new source are offset by at least an equivalent reduction of emissions from existing sources. One approach available to states is to create margins for growth by requiring additional emission reductions from existing sources in the SIP. Alternatively, a state may elect to implement an offset policy. Under an offset policy, the owner of the proposed new source must negotiate reductions from existing sources.

Not only must emissions of new major sources be offset by reductions from existing sources, but the new source must also meet the Lowest Achievable Emission Rate (LAER). LAER must be the lower of either the most stringent limitation in any SIP for that source category or the most stringent limitation available in practice for that type of source. Because these standards change over time, LAER is determined on a case-by-case basis. LAER must be at least as stringent as NSPS and generally should be more stringent than the emission rates achievable with BACT.

Each major new source constructed in a nonattainment area is subject to LAER. Under regulations requiring LAER, a major source is defined as one having the potential to emit more than 100 tons per year of a pollutant. LAER is not required for sources emitting less than 100 tons per year of a pollutant. For most industries, fugitive emissions are not counted in the annual emission rate used to determine if LAER is required. Fugitive emissions are those emissions exiting indirectly from an emissions source, e.g., leaks and emissions that escape during loading and unloading material. However, fugitive emissions are counted for the source categories listed in Table A1.2. The inclusion of fugitive as well as process emissions for those 28 categories effectively lowers the tons per year emission threshold for LAER.

Table A1.2. Source categories subject to PSD regulations*

- Fossil fuel-fired steam electric plants (> 250 million Btu/hr heat input)
- Coal cleaning plants (thermal dryers)
- Kraft pulp mills
- Portland cement plants

- Primary zinc smelters
- Iron and steel mill plants
- Primary aluminum ore reduction plants
- Primary copper smelters
- Municipal incinerators (capable of charging > 250 tons refuse/day)

- Hydrofluoric, sulfuric, nitric acid plants
- Petroleum refineries
- Phosphate rock processing plants
- Coke oven batteries
- Sulfur recovery plants

- Carbon black plants
- Lime plants
- Furnace process: primary lead smelters, fuel conversion plants, sintering plants
- Secondary metal production facilities

- Chemical process plants
- Fossil fuel boilers (> 250 million Btu/hr heat input)
- Petroleum storage and transfer facilities (capacity > 300,000 barrels)
- Taconite ore processing facilities

- Glass fiber processing plants
- Charcoal production facilities

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*If having the potential to emit at least 100 tons per year of any pollutant.

Federal Programs for Existing Sources

There are two federal programs that cover existing emissions sources. National Emission Standards for Hazardous Air Pollutants (NESHAPs) cover both new and existing sources, and Best Available Retrofit Technology (BART) is applied to existing sources. Each is discussed separately below.

NESHAPs. NESHAPs set limitations for specific hazardous pollutants from specified sources. Many of the regulations are generic, covering many types of sources that emit the specified pollutant (40 CFR 61). The Clean Air Act defines a hazardous air pollutant as one "to which no ambient air quality standard is applicable and which causes or contributes to air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness," [CAA, Section 112 (a)(1)]. NESHAPs have been established for asbestos, beryllium, beryllium rocket motor firing, mercury, and vinyl chloride. NESHAPs also have been proposed to limit benzene emissions from several sources.

BART. The federal visibility protection program was designed to prevent or remedy visibility impairment in mandatory class I Federal areas 1/ (CAA, Section 169A; 40 CFR 51.300). The regulations require the installation of BART by major existing stationary sources in operation on August 7, 1977, and not in operation prior to August 7, 1962. Under regulations requiring BART, major stationary sources are defined as sources listed in Table A1.2 that have the potential to emit more than 250 short tons per year of any one pollutant.

Regulations Covered in the Cost of Clean Air Report

The Cost of Clean Air Report includes the cost of compliance with SIPs, NSPS, NESHAPs and in a few instances, BACT or LAER. The term "SIP" is used in this report to refer to the state regulations that are mandated by the Clean Air Act but not included in other federal programs such as NSPS or NESHAPs.

SIP costs are usually estimates of the cost of complying with either an average SIP standard or the standard established by the majority of SIPs. Either of these control levels is often achievable with RACT (40 CFR 51, Appendix B). States often differentiate between new and existing sources in setting emission limits. New sources are generally required to meet more stringent standards. This does not necessarily imply greater control costs for new sources, however, because it is often less expensive to install pollution controls during plant construction than it is to retrofit them. In cases where there are significant compliance cost

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1/ An area designated as mandatory class I under the PSD program (see footnote 1, page 8) has the lowest maximum allowable ambient air concentration of criteria pollutants of the three classes of PSD areas and may not be designated as other than a class I area.

differences between new and existing sources, SIP costs may be estimated separately for each.

BACT and LAER are not costed separately except where information was available from a detailed industry study (Electric Utilities and Iron and Steel). The BACT and LAER compliance costs are difficult to estimate because of the source-specific nature of the regulations. BART compliance costs are not available. The regulation discussion in each chapter does not review the BACT, LAER, or BART regulations, which were described earlier in this section.

Control Technologies

The following discussion provides a brief description of the most widely used control devices installed on stationary sources in manufacturing industries. Three of the devices are used solely for particulate matter control -- mechanical collectors, electrostatic precipitators, and fabric filters. Wet scrubbers are used to control both particulate matter and sulfur dioxide. Combustion devices are used primarily to control volatile organic compound (VOC) and carbon monoxide emissions; they also remove particulate matter. Three other techniques are used for VOC control - adsorption, absorption, and refrigeration.

Mechanical collectors are low efficiency particulate control devices that remove larger particles with relatively simple capture mechanisms. Settling chambers and cyclones are the most common types of mechanical collectors. Settling chambers use gravity to collect particles on multiple trays and ultimately on the bottom surface of the chamber by controlling the velocity of the gas stream as it passes through the chamber. Cyclones employ centrifugal force in a turning gas stream to force particles against cylindrical walls. Particles are collected for discharge at the bottom of the cyclone collector while clean gas passes out the top through a center tube.

Mechanical collectors are normally chosen to improve the efficiency of other control devices or of the production process itself. Their own relatively low removal efficiency is insufficient to meet most federal air pollution control standards.

Electrostatic precipitators (ESPs) remove sub-micron-sized particle matter from large volume gas streams that are easily ionized. The ESP charges particles with electrical energy by passing the gas stream through an electrostatic field. The particles are neutralized and collected on a surface with opposite polarity and removed by mechanical devices. Collection efficiency, which can exceed 99 percent, depends on the length of time particles are exposed to the electrostatic field, the strength of the field, and the resistivity of the particles, a factor that varies with temperature and the moisture content of the gas.

Fabric filters achieve high efficiency particulate removal from gas streams with dry particulates or process gases with water in the vapor state. The fabric filter, also called a baghouse, is composed of compartments of filter bags or tubes. As the gases are forced through each compartment, particles are captured on the surface of the fabric bags. After a period of particulate collection, the filter surfaces are cleaned.

Fabric filters are often classified according to the method of cleaning: shaker type, reverse air, or pulse jet. The cleaning method depends on the durability of the fabric material. Cleaning can take place continuously during the filtering process or intermittently, between periods of filtering. The removal efficiency of the unit, which can exceed 99 percent, varies according to the air-to-cloth ratio, type of material, and the characteristics of the gas stream.

Wet scrubbers may be installed solely for particulate collection or as part of a flue gas desulfurization (FGD) system. FGD systems collect both particulate and sulfur dioxide emissions from boilers. The most common type of wet scrubber is the venturi scrubber, which achieves collection efficiencies higher than 99 percent for one micron or larger particles and from 90 to 99 percent for smaller particles. The venturi scrubber removes suspended particles from gas streams by generating atomized droplets; these droplets entrap particles in the gas stream through collision and agglomeration. A separator removes the agglomerates from the gas stream, usually by centrifugal force.

FGD systems include both a scrubber and a gas cooler in the separator. The gas cooler serves as an absorber for removing sulfur dioxide for the flue gas. Sulfur dioxide in the flue gas reacts with the scrubbing solution and forms a sludge. The sludge is then disposed of in a landfill. Sulfur dioxide removal efficiency can range from 80 to 95 percent.

Combustion devices are primarily installed to control VOCs, carbon monoxide, and odorous compounds, although they also remove particulate matter. They are most efficiently applied to sources with combustible gases, low gas flow rates, and low particulate concentrations. The exhaust or fugitive process gases are directed through vents to a combustion chamber for combustion to carbon dioxide and water vapor.

Incinerator systems (also called "afterburners") are categorized into two types according to the burning mechanism: (1) direct and thermal and (2) catalytic. Direct and thermal incinerators are similar; both rely on simple combustion. The difference between them is that thermal incinerators require additional fuel to achieve combustion. Thermal incinerators can achieve removal efficiencies in excess of 95 percent.

Catalytic incinerators employ a catalyst bed to achieve combustion at a lower temperature than thermal incinerators; they are better suited for gas streams containing organic vapors or solvents. Their removal efficiency depends on the catalyst characteristics, gas velocity, oxygen concentration, operating temperature, and waste gas concentration.

The cost-effectiveness of incineration can sometimes be improved by making use of the heat generated in the incineration process. The heat may be used either as an aid in the combustion process itself (primary heat recovery) or to generate steam for use in other processes (secondary heat recovery).

Adsorbers remove organic liquid and vapors from process streams that do not contain particulates or water-soluble compounds. Adsorbent materials must be highly porous for gas molecule penetration and have a large surface area. The most widely used adsorbent is carbon.

The process waste stream is cleaned when pollutant compounds are mechanically and chemically bonded to the granular surface of the adsorbent. Removal efficiency is nearly 100 percent during initial adsorption. When the adsorbent becomes saturated and efficiency begins to drop, the adsorbent is regenerated at a high temperature to remove the pollutants. Both the captured vapors and the adsorbent are recovered for reuse after regeneration.

Absorbers are primarily used to control VOC emissions. The absorbent, a liquid solvent, removes gaseous pollutants from a process stream by dissolving or chemically combining with the solute of gaseous organic compounds. The liquid-gas mixture can then be desorbed to remove the solute and recover the solvent, or it may simply be returned to storage with the volatile organic liquid that was the source of the emission.

Absorption is most commonly used for recovering hydrocarbons from petroleum storage and transfer operations. In many cases it is used in conjunction with other pollution control techniques.

Refrigeration removes pollutants from a gas stream by condensation. Gaseous pollutants are condensed for removal or recovery when the gas stream is cooled. One of two different cooling processes may be used. Surface condensers refrigerate the vapors without contact, by cooling the walls that separate coolant from vapor. Contact condensers cool the vapor by spraying the coolant on the gas stream.

Vapor recovery systems used in collecting VOC emissions from storage and transfer of volatile organic liquids employ refrigeration and condensation as stages of the process. Refrigeration is often used in conjunction with other control techniques. It must generally be followed by a secondary control system to treat the non-condensible gases. Refrigeration can also be employed to condition the solvent in absorption systems.

Cost Methodology

Cost estimates for each industry are presented in a table following the corresponding chapter text. To estimate compliance costs the industry is usually divided into a number of sectors. Sectors are defined according to production process, control technology, regulations, available cost data, or any other factors that can influence costs. The cost data for an individual sector may take one of two forms: "exogenous" total costs, or cost functions. The cost methodology section in each chapter indicates the type of cost data used in that chapter.

Exogenous costs are calculated outside the computer model for the report. The exogenous form is sometimes used because the complexity of the chapter precludes the use of cost functions alone. In other instances, these costs are taken from a detailed economic study of the industry commissioned by the EPA. The use of these studies improves the consistency and coherency of this report with other EPA publications. Some of these economic reports may not provide detailed information about control costs. In these cases the reported costs do not necessarily conform to the standard format, e.g., new plant costs may not be separately identified, although costs projected into the future include costs for both new and existing plants. Similarly, the source document may not use the same breakdown of annual costs or the same interest rate as is normally used in the existing computer model. Nevertheless, the overall costs and timing of the costs are reported as developed in the designated source document.

Costs in most chapter sectors are generated from cost equations that express control costs as a function of plant capacity. (Larger plants usually benefit from economies of scale.) In most cases future cost estimates are based on the assumption of continued application of current technologies. Capital and operating and maintenance costs are calculated separately. The computer program computes total industry costs by applying the cost functions to industry plant data, taking into account compliance schedules estimated by the chapter author. The cost functions, which are based on engineering model plant costs, are expressed in a standard exponential form: $Cost = AX^B$, where X is a measure of capacity. O&M costs are adjusted according to estimates of capacity utilization percentages. Industry plant data include the plant population for a base year, historical growth rates, and expected future growth rates. Compliance information is simply the percentage of the plant population that complied with a regulation in each past year and estimates of the percentage that will comply in each future year. These estimates are based on the compliance date specified in the pertinent regulation, allowing for lead time required to construct and install the control technology required. New plants are assumed to comply upon construction.

To calculate the annual cost of capital, the computer program uses the stated life of the control equipment and a real, before-tax interest rate of ten percent. The interest rate accounts for the "opportunity" cost of control equipment investment funds. Moreover, because income taxes are not considered, these costs represent the total costs to society for pollution control. It is understood that other systems of depreciation are used, that other interest rates are sometimes applicable, that "opportunity costs" for other uses of capital are not taken into account, and that tax write-offs are commonly applied to control equipment. The ten percent interest rate is used as a "compromise" value which is intended to reflect an average value of the highly varied individual cases.

The computer program also calculates the cost of replacing control equipment at the end of its useful life. These costs are assumed to be some fraction of the original cost of equipment as certain elements, such as the foundations, do not need to be replaced.

The program excludes costs associated with air pollution control that would have been incurred without the inducement of federal regulations. It does this by excluding from the plant population a precompliance fraction that is provided by the chapter author. This fraction represents plants that either can comply with the applicable regulation without installing controls or plants that installed controls even in the absence of regulations. When estimating compliance costs for SIPs, this precompliance fraction may also include the percentage of the plant population not regulated by SIPs. (Some plants are not covered by SIPs because they are located in states whose SIPs do not have regulations governing the industry or because certain plants are exempted by the SIPs.)

When pollution control results in product or by-product recovery, the value of the recovered product is calculated and credited against the O&M costs associated with the control. Credits are estimated by multiplying the price of the recovered product by the amount of the recovered product. In some cost sectors, the O&M costs or cost function have been estimated net of credits. In other cases, credits or credit functions have been estimated separately. In credit function sectors, credits, like costs, are expressed as an exponential function: Credit = AX^b, where X is a measure of capacity. Credits, in the same way as O&M costs, are adjusted according to capacity utilization estimates. In cases when credits exceeded costs on an annualized basis for a sector, it was assumed that the control technique would be adopted for economic reasons. Neither the sectors costs nor credits were included in the cost estimates of this report.

The bulk of the cost estimates are for compliance with SIP, NSPS, and NESHAP regulations. Very little information is available on BACT and LAER costs; NSPS costs were often used as a surrogate. Except where NESHAPs are involved, there is also very little information available on fugitive emission control costs. The report does not include cost estimates for most fugitive emission controls.

Most cost estimates presented in this report are based on the cost of installing and operating controls to meet standards at each regulated source. Thus, they do not reflect less costly control strategies available for some facilities either through creation of emission bubbles or by trading emission reduction credits with other facilities.

This cost methodology differs from that followed in the August, 1979 report in that it:

1. includes estimates of replacement costs, and

2. does not assume that any fraction of industry was controlling emissions to the level set by New Source Performance Standards before the promulgation of these standards.

TABLE A1.3 GOVERNMENT
AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
				INVESTMENT		
A 2.	GOVERNMENT	0.0	0.0	0.0	0.0	0.0
				ANNUAL COSTS		
A 2	GOVERNMENT	606.00	7118.00	2208.00	3807.0	5265.00

TABLE A1.3 ENERGY INDUSTRIES AIR POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 3. 1	POWER PLANTS	2497.98	4758.16	6006.99	12992.43	25959.84
A 3. 2	IND. & COMM. HEATING BOILERS	438.80	4281.55	1600.75	3751.24	7136.02
A 3. 3	NATURAL GAS PROCESSING	4.71	9.81	9.08	25.60	70.30
A 3. 4	PETROLEUM REF.	113.71	666.69	298.97	499.30	691.19
A 3. 5	COAL CLEANING	1.77	51.62	5.14	10.81	22.80
A 3. 6	COAL GASIFICATION	0.0	0.0	0.0	0.0	56.23
A 3. 7	WOOD WASTE BOILERS	0.86	87.66	2.78	44.10	111.27
	TOTAL INVESTMENT	3057.84	9855.50	7923.70	17323.47	34047.64

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 3. 1	POWER PLANTS	7452.62	20941.11	21060.46	46351.02	95678.69
A 3. 2	IND. & COMM. HEATING BOILERS	2499.11	5578.79	6546.61	14190.84	26056.77
A 3. 3	NATURAL GAS PROCESSING	5.27	10.83	11.97	36.73	132.27
A 3. 4	PETROLEUM REF.	168.83	468.72	435.55	1018.55	2041.50
A 3. 5	COAL CLEANING	16.97	66.74	48.07	105.10	178.10
A 3. 6	COAL GASIFICATION	0.0	0.0	0.0	0.0	302.20
A 3. 7	WOOD WASTE BOILERS	47.88	171.23	140.33	292.11	541.96
	TOTAL ANNUAL COSTS	10190.68	27237.42	28242.98	61994.34	124931.31

TABLE A1.3 MOBILE SOURCES
AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
				INVESTMENT		
A 4.	MOBILE SOURCES	4581.41	22803.54	13649.57	28654.07	58978.92
				ANNUAL COSTS		
A 4.	MOBILE SOURCES	6047.33	55098.63	17806.84	37792.27	80554.48

TABLE A1.3 CHEMICAL
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 5. 1	PETROCHEMICALS	11.41	31.82	37.94	70.54	127.83
A 5. 2	VINYL CHLORIDE	14.02	111.27	223.38	268.98	169.07
A 5. 3	NITRIC ACID	0.41	48.32	18.42	21.00	63.09
A 5. 4	SULFURIC ACID	19.76	570.10	128.89	212.65	719.79
A 5. 5	PHOSPHATE FERTILIZER	6.62	114.21	18.16	42.16	170.10
A 5. 6	NONFERTILIZER PHOSPHATES	0.20	9.95	0.60	1.22	6.02
A 5. 7	MERCURY-CELL CHLOR-ALKALI	0.0	18.81	0.0	0.0	14.14
A 5. 8	AMMONIA & UREA	5.62	12.56	15.27	22.90	16.39
A 5. 9	AMMOMIUM NITRATE FERTILIZERS	0.11	0.10	0.28	0.43	0.27
	TOTAL INVESTMENT	58.14	917.15	442.93	639.88	1286.70

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 5. 1	PETROCHEMICALS	11.90	9.03	30.13	78.91	182.35
A 5. 2	VINYL CHLORIDE	96.34	51.37	269.65	588.07	1203.20
A 5. 3	NITRIC ACID	25.27	42.67	75.13	152.30	260.24
A 5. 4	SULFURIC ACID	298.02	769.72	837.80	1749.02	2802.32
A 5. 5	PHOSPHATE FERTILIZER	29.26	110.01	85.31	179.09	348.42
A 5. 6	NONFERTILIZER PHOSPHATES	1.77	4.93	5.20	10.75	19.64
A 5. 7	MERCURY-CELL CHLOR-ALKALI	7.77	27.96	23.65	50.81	96.98
A 5. 8	AMMONIA & UREA	5.91	6.47	14.19	36.97	75.66
A 5. 9	AMMOMIUM NITRATE FERTILIZERS	0.13	0.06	0.29	0.84	1.70
	TOTAL ANNUAL COSTS	476.36	1022.22	1341.34	2846.77	4990.48

TABLE A1.3 METALS
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

CHAPTER	INDUSTRY	INVESTMENT 1981	1970-78	1979-81	1979-84	1981-90
A 6. 1	IRON & STEEL	195.00	1798.00	809.00	1980.00	2124.00
A 6. 2	IRON FOUNDRIES	14.61	381.19	48.74	81.52	110.70
A 6. 3	STEEL FOUNDRIES	11.55	89.18	33.92	55.42	78.94
A 6. 4	FERROALLOYS	0.0	206.65	0.0	0.0	0.0
A 6. 5	PRIMARY ALUM.	15.33	370.15	52.11	261.92	549.78
A 6. 6	PRIMARY COPPER	53.90	1926.30	161.70	342.10	387.40
A 6. 7	PRIMARY LEAD	0.0	3.15	1.05	10.28	27.39
A 6. 8	PRIMARY ZINC	0.0	20.95	8.41	8.41	11.29
A 6. 9	SECONDARY ALUM	1.88	24.11	8.87	15.22	34.07
A 6.10	BRASS &BRONZE	0.40	19.39	1.16	2.48	13.16
A 6.11	SECONDARY LEAD	0.0	13.18	4.15	97.08	139.39
A 6.12	SECONDARY ZINC	0.01	0.02	0.03	0.03	0.01
	TOTAL INVESTMENT	292.68	4852.27	1129.13	2854.46	3476.14

CHAPTER	INDUSTRY	ANNUAL COSTS 1981	1970-78	1979-81	1979-84	1981-90
A 6. 1	IRON & STEEL	1212.75	3512.26	3353.98	8128.00	17330.83
A 6. 2	IRON FOUNDRIES	99.75	413.61	292.22	599.99	1053.80
A 6. 3	STEEL FOUNDRIES	27.58	47.79	74.75	169.60	339.33
A 6. 4	FERROALLOYS	50.63	224.06	151.88	303.76	467.72
A 6. 5	PRIMARY ALUM.	169.91	644.39	492.55	1038.28	1970.94
A 6. 6	PRIMARY COPPER	416.02	1844.68	1229.39	2465.64	3643.82
A 6. 7	PRIMARY LEAD	0.73	1.06	2.13	7.43	42.55
A 6. 8	PRIMARY ZINC	5.52	25.15	16.57	33.13	54.28
A 6. 9	SECONDARY ALUM	9.32	21.58	26.25	58.07	125.54
A 6.10	BRASS &BRONZE	4.79	12.88	13.32	28.15	49.83
A 6.11	SECONDARY LEAD	2.04	3.46	6.11	45.75	255.09
A 6.12	SECONDARY ZINC	0.02	0.02	0.05	0.11	0.24
	TOTAL ANNUAL COSTS	1999.05	6750.93	5659.20	12877.90	25333.94

TABLE A1.3 MINERAL-BASED INDUSTRIES AIR POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 7. 1	CEMENT	11.72	96.92	34.74	70.75	169.15
A 7. 2	STRUCTURAL CLAY PRODUCTS	14.40	27.80	42.77	86.85	147.04
A 7. 3	LIME	2.91	95.80	8.49	17.68	90.19
A 7. 4	ASPHALT CONCR.	10.01	429.00	43.53	74.51	374.65
A 7. 5	ASPHALT ROOFING	3.12	17.22	9.20	17.49	26.80
	TOTAL INVESTMENT	42.15	666.74	138.73	267.28	807.82

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 7. 1	CEMENT	39.91	119.00	109.11	250.58	562.65
A 7. 2	STRUCTURAL CLAY PRODUCTS	27.74	16.21	66.15	184.62	488.79
A 7. 3	LIME	53.51	205.38	155.93	326.15	611.79
A 7. 4	ASPHALT CONCR.	165.91	654.14	488.70	1005.05	1785.43
A 7. 5	ASPHALT ROOFING	5.67	12.65	14.96	33.42	59.31
	TOTAL ANNUAL COSTS	292.73	1007.39	834.85	1799.83	3507.96

TABLE A1.3 MANUFACTURING & SERVICES
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 8. 1	PAINT MFG.	3.39	6.83	10.20	20.31	31.98
A 8. 2	SURFACE COATING	120.23	167.78	350.97	739.22	1005.24
A 8. 3	DRY CLEANING	0.0	0.0	0.0	142.79	407.98
A 8. 4	PRINTING INK MFG.	2.85	24.23	9.80	20.87	47.15
A 8. 5	SYNTHETIC FIBER MFG.	0.12	2.56	0.44	1.29	3.86
A 8. 6	LEAD ACID BATTERIES	0.0	21.35	0.0	0.02	15.92
	TOTAL INVESTMENT	126.59	222.76	371.41	924.51	1512.13

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 8. 1	PAINT MFG.	4.77	2.88	11.46	31.38	79.30
A 8. 2	SURFACE COATING	115.49	59.20	265.99	776.24	2209.04
A 8. 3	DRY CLEANING	0.0	0.0	0.0	40.22	466.61
A 8. 4	PRINTING INK MFG.	21.10	51.15	56.63	125.77	255.44
A 8. 5	SYNTHETIC FIBER MFG.	1.82	5.78	5.26	11.15	21.63
A 8. 6	LEAD ACID BATTERIES	6.29	25.28	18.86	37.73	63.83
	TOTAL ANNUAL COSTS	149.46	144.28	358.20	1022.49	3095.85

TABLE A1.3 FOREST & AGRICULTURAL PRODUCTS INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 9. 1	KRAFT PAPER	71.88	1323.53	212.40	391.73	472.76
A 9. 2	NSSC PAPER	0.0	72.03	0.0	0.0	0.0
A 9. 3	GRAIN ELEVATORS	24.24	441.96	155.86	233.45	497.74
A 9. 4	FEED MILLS	10.95	567.99	31.89	66.83	414.71
A 9. 5	PLYWOOD VENEER	2.05	2.43	4.89	11.80	19.31
	TOTAL INVESTMENT	109.12	2407.95	405.04	703.82	1404.52

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 9. 1	KRAFT PAPER	347.32	1018.31	993.41	2125.26	3744.73
A 9. 2	NSSC PAPER	15.52	39.50	45.38	91.95	146.74
A 9. 3	GRAIN ELEVATORS	14.95	37.84	41.08	92.17	193.50
A 9. 4	FEED MILLS	136.78	436.32	396.58	824.05	1489.55
A 9. 5	PLYWOOD VENEER	1.66	1.06	3.60	11.77	35.15
	TOTAL ANNUAL COSTS	516.24	1533.03	1480.06	3145.19	5609.66

TABLE A1.3 SOLID WASTE REDUCTION
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A10. 1	MUNICIPAL WASTE INCINERATION	5.32	71.02	38.63	58.58	57.10
A10. 2	INDUSTRIAL & BUILDING INCINERATORS	92.83	281.09	194.10	472.58	578.08
	TOTAL INVESTMENT	98.15	352.11	232.73	531.16	635.19

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A10. 1	MUNICIPAL WASTE INCINERATION	25.62	51.21	79.29	155.17	250.13
A10. 2	INDUSTRIAL & BUILDING INCINERATORS	156.97	313.08	392.59	1048.09	2488.41
	TOTAL ANNUAL COSTS	182.58	364.30	471.88	1203.26	2738.53

Chapter A2 Government

This chapter presents estimates of expenditures made by federal, state, and local governments for both air pollution control programs and control of air pollution emitted from government facilities.

The principal expenditures in the government sector are programmatic--for research, monitoring, administration, and enforcement. Research is supported primarily by federal funds. Most state and local funds, supplemented by federal grants, are directed toward the development of regulations, monitoring, and enforcement.

Governments also incur the cost of meeting air pollution standards at government facilities. At the federal level, the Department of Defense, the Tennessee Valley Authority, and the Department of Energy are the major sources of such expenditures.

Table A2.1 presents the pollution control expenditures made by EPA, non-EPA federal agencies, and state and local governments. The EPA expenditures are also reported in Table A2.2, disaggregated according to administration, enforcement, research and development, and grants to state and local governments. The grants to state and local governments are subtracted from the EPA total in Table A2.1, because they are included with the state and local government expenditures in Table A2.1.

Table A2.3 summarizes total government expenditures. Because of the nature of the data, total costs are not divided between capital and O&M costs components.

Table A2.1 Federal, state, and local expenditures
on air pollution control
(by fiscal year in millions of 1981 dollars)

Year	EPA[a]	Non EPA federal[b]	Total federal	State & local[c]	Total
1970	185	190	375	149	524
1971	169	292	461	183	644
1972	191	493	684	245	929
1973	213	613	826	261	1087
1974	185	619	804	204	1008
1975	175	303	478	188	666
1976*	189	235	424	204	628
1977	159	336	495	278	773
1978	144	372	516	343	859
1979	193	308	501	354	855
1980	233	280	513	234	747
1981	145	228	373	233	606
1982	135	226	361	218	579
1983	115	189	304	206	510
1984	115	189	304	206	510
1985	115	189	304	206	510
1986	115	189	304	206	510
1987	115	189	304	206	510
1988	115	189	304	206	510
1989	115	189	304	206	510
1990	115	189	304	206	510

*Includes transition quarter

Sources: [a] Table A2.2.

[b] U.S. Office of Management and Budget, Special Analyses Section 52.2, 1980, 1982 and 1984 Budget of the U.S. Government, Appendix to the Budget of the U.S. Government. For updated air pollution control expenditures refer to the 1985 Budget of the U.S. Government.

[c] EPA, Office of the Comptroller, includes federal grants and state matching share.

Table A2.2. U.S. EPA air pollution control expenditures by category
(by fiscal year in millions of 1981 dollars)
(values independently rounded)

Year	Administration	Enforcement	Research & development	Total	Grants to state and local govts.**
1971	83	--	140	223	52
1972	103	--	116	219	65
1973	155	3	119	277	84
1974	163	7	133	303	92
1975	145	16	97	258	72
1976*	135	17	87	239	66
1977	162	22	93	277	89
1978	139	21	73	233	75
1979	138	27	57	222	78
1980	214	35	77	326	93
1981	147	29	59	235	90
1982	133	27	60	220	84
1983	119	18	53	190	77
1984	119	18	53	190	77
1985	119	18	53	190	77
1986	119	18	53	190	77
1987	119	18	53	190	77
1988	119	18	53	190	77
1989	119	18	53	190	77
1990	119	18	53	190	77

*Includes transition quarter.
**These grants are included in the administration category.

Sources: Hearings before a subcommittee of the Committee on Appropriations. U.S. House of Representatives EPA Budget Preparation and Control Division. U.S. Budget. Environment and Natural Resources Section, CEQ, Environmental Quality 1971. Cost of Clean Air, EPA, 1973. EPA Grants Assistance Division Appendix to the 1980 U.S. Budget. EPA Justification of Appropriation Estimate for the Committee on Appropriations, FY 1983 and FY 1982.

Table A2.3. Government

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	0.0
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	0.0
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	606.00	7118.00	2208.00	3807.00	5265.00
TOTAL ANNUAL COSTS	606.00	7118.00	2208.00	3807.00	5265.00

Chapter A3. Energy Industries

For the purpose of this report, the broad category "Energy Industries" was defined to include those industries which gather, transfer, process, and deliver energy to the consumer. These include: Fossil-Fuel-Fired Electric Power Plants, and, because of the similarities with other industries included in this category with respect to technology, Industrial and Commercial Heating Boilers. Also included are a group of industries which process and deliver fuels to various consumers. These include:

- Natural Gas Processing
- Petroleum Refining
- Coal Cleaning
- Coal Gasification
- Wood Waste Boilers

One important and relevant subject that is not included here appears in another Chapter.

- Producing and using gasoline with little or no lead is discussed in Chapter 4, "Mobile Sources."

Air pollution abatement costs are summarized in Table A3.

TABLE A 3. ENERGY
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A. 3. 1	POWER PLANTS	2037.90	6750.16	6006.99	12992.43	25959.84
A. 3. 2	IND. & COMM. HEATING BOILERS	638.80	4281.55	1600.75	3751.24	7136.02
A. 3. 3	NATURAL GAS PROCESSING	6.71	9.01	9.08	25.60	70.30
A. 3. 4	PETROLEUM REF.	113.71	664.69	290.97	499.30	691.19
A. 3. 5	COAL CLEANING	5.77	51.62	5.10	10.81	22.80
A. 3. 6	COAL GASIFICATION	0.0	0.0	0.0	0.0	56.23
A. 3. 7	WOOD WASTE BOILERS	0.86	87.66	2.78	44.10	111.27
	TOTAL INVESTMENT	3057.04	9055.50	7923.70	17323.47	34047.64

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A. 3. 1	POWER PLANTS	7852.62	20981.11	21060.66	46351.02	95678.69
A. 3. 2	IND. & COMM. HEATING BOILERS	2089.11	5578.70	6586.61	14190.04	26056.77
A. 3. 3	NATURAL GAS PROCESSING	5.27	10.03	11.97	36.73	132.27
A. 3. 4	PETROLEUM REF.	160.03	660.72	635.55	1018.55	2041.50
A. 3. 5	COAL CLEANING	16.97	66.78	40.07	105.10	178.10
A. 3. 6	COAL GASIFICATION	0.0	0.0	0.0	0.0	302.20
A. 3. 7	WOOD WASTE BOILERS	67.80	170.23	140.33	292.11	541.96
	TOTAL ANNUAL COSTS	10190.60	27237.02	28262.90	61994.34	124931.31

Chapter A3.1 Fossil-Fuel-Fired Electric Plants

This chapter covers the cost of compliance with SIPs and NSPS by fossil-fuel-fired boilers and stationary gas turbines in electric utility power plants. Estimated costs include the cost of equipment that controls particulate, sulfur dioxide, and nitrogen oxides emissions and premiums paid for low sulfur fuel to reduce sulfur dioxide emissions during combustion.

Industry Characteristics

Electric utilities produce 97 percent of the electricity generated in the United States; the remainder is generated by industrial and commercial establishments. Most utility power plants generate electricity by producing steam from burning fossil fuels (coal, oil, and gas). Other plants are powered by water (hydro) or nuclear power.

This section discusses the ownership, capacity, and production of all types of power plants. It also describes the distribution of fuel use by fossil-fuel-fired power plants and gas turbines.

Ownership. Both private companies and public agencies (municipalities and federal agencies) own electric utility systems. All of these utilities, because of their monopoly position in local markets, are regulated by local or state governments. Most private companies and municipalities both generate and distribute electricity to industries, commercial establishments, and residences. The federal agencies, however, only operate the generating units. They sell the electricity to local service companies or rural cooperatives for distribution to consumers.

About 200 private utility companies operate 80 percent of total installed capacity and 90 percent of steam generating capacity. Half of the publicly owned capacity is operated by almost 200 municipalities, and half by five federal agencies. One of the federal agencies, the Tennessee Valley Authority, controls the largest electricity generation system in the United States.

In 1979 revenues from sales of electricity totalled $71 billion for private companies, $6 billion for municipalities, and $2 billion for federal agencies. Utilities are classified into SIC 4911, Electric Services.

Capacity and Production. Installed utility capacity in 1980 totalled 614 million kilowatts, and electricity production totalled 2.3 trillion kilowatt hours. Both capacity and production increased at about 5 percent per year between 1970 and 1980. Production is expected to increase at less than 2 percent per year through 1990.

During the 1970's, there was a change in the distribution of total capacity and production by type of unit. The use of steam generation and hydropower declined relative to nuclear power. Both the capacity and electricity generation of steam powered units fell from 83 to 78 percent of the total, while that of hydropower plants fell from 16 to 12 percent, and that of nuclear power plants increased from 1 to 10 percent. In the next ten years, the fraction of total electricity production is expected to fall for steam generation, to remain unchanged for hydropower, and to continue growing for nuclear power.

Distribution of Fossil-Fuel-Fired Units. There are 934 power plants with fossil-fuel-fired boilers (steam generators) and 541 with gas turbines. Most utility boilers have a capacity larger than 73 megawatts (250 million Btu per hour) although some are as small as 30 megawatts (100 million Btu per hour). They are designed to burn coal, oil, gas, or a combination of these fuels. Utility gas turbines, which have a capacity between 15 and 100 megawatts (50-350 million Btu per hour), burn only oil or gas.

Between 1970 and 1980, conventional steam power plant capacity increased 40 percent from 260 to 425 million kilowatts. The average annual capacity utilization rate, called the load factor, for these boilers ranges from 0.3 for natural gas and distillate oil units to 0.6 for coal units. These factors are low because the seasonal demand for electricity requires utilities to maintain excess capacity.

There are currently more than 2,000 steam electric generating units. Forty-seven percent burn coal, and the remainder are fairly equally divided among those burning oil, gas, and a combination of oil and gas. The coal-fired units account for 60 percent of capacity, with the remaining capacity equally divided among the other three categories.

Stationary gas turbine capacity at power plants more than tripled, from 16 to 51 million kilowatts, in the 1970's. Because gas turbines are only used at peak load periods, each one is operated an average of only 500 hours a year. As a result, gas turbines provide only 1.5 percent of fossil-fuel-fired power generated by utilities.

Utilities consume 8 percent of coal, 5 percent of distillate oil, 50 percent of residual oil, and 20 percent of natural gas sold in the United States. Between 1970 and 1980, the consumption of coal by utilities increased at 5 percent per year to 590 million short tons. Oil consumption increased at 8 percent per year from 1970 to 1978. It then fell at 20 percent per year, reaching 36 million barrels in 1981. Natural gas consumption declined between 970 and 1976 at an annual rate of 4 percent and then increased between 196 and 1980 (to 3.7 trillion cubic feet), also at a 4 percent annual rate. In the 1980's, utility demand for fuels is expected to increase at 2 percent per year for coal and to decrease at 5 to 6 percent per year for oil and gas.

The substitution of coal for oil reflects the relatively higher price for oil. It also reflects Department of Energy policies that discourage the use of oil and gas and require that all newly constructed boilers burn coal. Oil and gas utility boilers were not ordered in the late 1970's and are not expected to be ordered in the future.

This forecast growth in utility boiler capacity reflects this substitution of coal for oil and gas. Between 1980 and 1990, coal-fired boiler capacity is expected to grow at 3.5 percent per year, oil and gas-fired capacity is expected to decline at an annual rate of 1.4 percent, and gas turbine capacity is expected to increase at 2.9 percent per year.

Emission Sources and Pollutants

Both steam generators (boilers) and stationary gas turbines emit air pollutants in their flue or exhaust gases. The type and level of emissions depend on fuel characteristics, equipment design, and various combustion factors.

Natural gas and distillate oil are considered clean fuels because of their low ash and sulfur content and their relative ease in burning with high efficiency. Coal and most residual oils contain significant amounts of sulfur and ash, require more sophisticated combustion equipment, and are more difficult to burn at high efficiencies.

This section discusses the operation and primary emissions of each type of utility boiler (coal, oil, and gas) and of stationary gas turbines.

Utility Boilers. All utility boilers are of the water-tube design. Air and fuel enter the combustion chamber of the boiler through multiple burners. The combustible matter reacts with oxygen in the air to release thermal energy. Water-filled tubes in the walls of the chamber absorb the thermal energy and generate steam. The steam turns the blades of the steam turbines in the generator, producing electricity. Superheat and reheat sections of the generator allow further stages of heat transfer and gas cooling, thus permitting efficient use of the combustion gases.

There are several types of water-tube boilers, which differ according to firing equipment, fuel handling system, and placement of the burners on the firing wall. The four most common types--tangential, single wall, horizontally opposed, and turbo furnace--can burn coal, oil, gas or a combination of these fuels.

Coal-fired utility boilers are primarily the pulverized type, firing coal that has been finely ground. There are also a few stoker utility boilers that burn coal.

Three types of coal-burning units--cyclone, vertical, and stoker--are no longer sold, but a few remain in use. Cyclone boilers cannot be adapted to meet emissions regulations. Vertical boilers primarily burn anthracite coal, which is declining in use, and stoker boilers have design capacity limitations.

In a pulverized boiler, part of the coal is burned in the fuel bed, and part in suspension. Particulate emissions from pulverized units are lower for boilers with the wet bottom than the dry bottom design. In a wet or slag bottom furnace, the temperature is maintained above the ash fusion temperature so that the ash is melted and can be removed from the furnace as a liquid or slag. Thus, as little as 50 percent of the ash is emitted in the flue gas. In a dry bottom furnace, the temperature is maintained below the ash fusion temperature so that the ash will not fuse. Nearly all the ash particles are formed in suspension, and about 80 percent of the ash leaves the furnace entrained in the flue gas.

The ash content of coal, along with type of combustion unit, fuel feed rate, and the degree of fly ash (ash in the flue gas) reinjection, determines the quantity of uncontrolled particulate emissions. A typical ash content for coal is 9 percent by weight, although it may range from 3 to 30 percent.

In a coal-fired furnace, from 90 to 95 percent of sulfur in the coal is converted to sulfur oxides, which are emitted in the flue gas. The balance of the sulfur is emitted in the fly ash or removed with the slag or ash in the furnace. Sulfur levels in coal range from trace amounts up to 8 percent by weight. Western low sulfur coals average 1.6 percent sulfur; Eastern medium sulfur coals average 2.2 percent sulfur; and Central high sulfur coals average 2.8 percent sulfur.

The nitrogen oxides emission rate, which is lower than that of particulates and sulfur oxides in coal-fired utility boilers, depends primarily upon the firing method. Among coal-fired utility boilers, the cyclone boilers have the highest emission rate, and tangential boilers have the lowest.

Oil- and gas-fired utility boilers burn liquid fuel in suspension. Combustion of residual oil results in much higher levels of particulate and sulfur dioxide emissions than combustion of distillate oil. Residual oil is the only liquid fuel with significant levels of ash. In boilers firing residual oil, however, particulate emission can be reduced by as much as 60 percent when the boiler is fired at low loads.

In fuel oil combustion, almost all of the sulfur in the fuel is converted to sulfur oxides. The sulfur content of residual fuel ranges from 0.5 to 2.0 percent, while that of distillate oil averages 0.25 percent, and that of natural gas, only a trace.

Nitrogen oxides emissions from firing residual oil are primarily organic, formed from the nitrogen content of the fuel. Almost all nitrogen oxide emissions from firing distillate oil and gas, which have low nitrogen content, are thermal, formed from nitrogen in the combustion air. The level of thermal nitrogen oxides emissions depends on the firing configuration. Nitrogen oxides emissions are the only significant emissions from gas-fired boilers.

Utility Stationary Gas Turbines. Stationary gas turbines are rotary internal combustion engines fueled by distillate oil, natural gas, or diesel fuel and occasionally by residual or crude oils. Air first enters a compressor where it is pressurized before passing to the combustion chamber. Fuel is then introduced into the chamber and burned.

Hot combustion gases are rapidly quenched by secondary dilution air and then expanded through the turbine, which drives the compressor and provides shaft power. The hot gases are further expanded across the power turbine blades that drive the electrical generators and then exit as exhaust gases.

The major pollutants emitted by stationary gas turbines are sulfur oxides and nitrogen oxides. As with oil-fired boilers, virtually all of the sulfur content in the fuel is converted to sulfur oxides. Organic nitrogen oxides are formed from burning fuels with nitrogen content while thermal nitrogen oxides emissions are generated with all fuel types. Because residual and crude oils have the highest sulfur and nitrogen content of the liquid fuels, turbines that burn these fuels have higher emission rates then those that burn other liquid fuels.

Regulations

Electric utility regulations in three NSPS and in SIPs govern fossil-fuel-fired utility steam generating units (boilers) and stationary gas turbines at power plants. These regulations set limits for particulate matter, sulfur dioxide, and nitrogen oxides from boilers, and sulfur dioxide and nitrogen oxides from stationary gas turbines.

NSPS. Two NSPS regulate all fossil-fuel-fired steam generators with a heat input rate of greater than 250 million Btu per hour. The NSPS (40 CFR 60.40) promulgated December 23, 1971, established limits for units that commenced construction after August 17, 1971, and before September 19, 1978. The revised NSPS (40 CFR 60.40a), promulgated June 11, 1979, set more stringent limits for units commencing construction after September 18, 1978.

The NSPS regulations include emission limits for particulates, sulfur dioxide, and nitrogen oxides. These limits vary according to the type of fuel burned (solid, liquid, and gaseous). The revised NSPS requires not only a limit on emissions from flue gas but also a reduction in potential pollutant concentration in combustion gases. This type of standard discourages the burning of low ash and low sulfur fuel as a control method and encourages the installation of flue gas control devices.

Another NSPS (40 CFR 60.330), promulgated September 10, 1979, covers nitrogen oxides and sulfur dioxide emissions from stationary gas turbines with heat input at peak load equal to or greater than 10.7 gigajoules per hour. This NSPS regulates the larger-sized turbines (greater than 10 million Btu per hour) that are operated by utilities during peak load periods.

SIPs. States establish general emission limits for particulates, sulfur dioxide, and nitrogen oxides from all combustion sources, including utility boilers and turbines. The regulations vary within and among states according to characteristics of the combustion source. These characteristics include heat input rate, age (new or existing), fuel type, facility size, and geographic location (attainment or non-attainment area).

The emission limits for sources with a heat input rate greater than 100 million Btu per hour apply to utility steam generating units. Utility stationary gas turbines are governed by the limits for sources with a heat input rate of over 50 million Btu per hour.

Particulate emission limits are more stringent for the large boilers than for the smaller turbines, but the sulfur dioxide regulations generally do not vary according to source size or heat input rate. For those SIPs that differentiate among fuel types, the sulfur dioxide limits for residual oil are generally more stringent than those for coal. Most of the sulfur dioxide regulations for existing sources are designed to be met by burning low sulfur fuel rather than by installing controls for reducing emissions in the flue gas.

Nitrogen oxides standards are included in only 16 SIPs. They generally apply to combustion sources with a heat input rate of greater than 250 million Btu per hour. In those 16 states most utility boilers that are not already covered by NSPS are affected by these limits.

Control Technology

Particulate Controls. Particulate emissions from utility boilers can be controlled with low efficiency mechanical collectors or with high efficiency controls such as electrostatic precipitators, wet scrubbers, and fabric filters. Each technology is discussed briefly below.

Mechanical collectors (cyclones) are capable of removing only larger particles. They do not achieve the level of efficiency required by the more stringent SIPs or by NSPS. Cyclones are placed on most coal-fired boilers without the inducement of federal regulations, because recirculating the larger particulates into the furnace for further burning increases boiler efficiency. Their costs are not included in this chapter.

Electrostatic precipitators (ESPs) are the most widely used particulate control technology for utility coal- and residual oil-fired boilers. Only a few utility coal-fired boilers have fabric filters. Both types of equipment can achieve removal efficiency above 99 percent.

Sulfur Dioxide Controls. Sulfur dioxide emissions can be controlled by removing the sulfur oxides from the combustion gases (flue gas desulfurization) or by switching to low-sulfur fuel. The use of low sulfur fuels rather than the installation of a flue gas control device has been encouraged by the emission standards in most SIPs. However, the most recent NSPS for large boilers, which requires a reduction in potential emissions in the flue gas, virtually requires a flue gas control device on newly constructed utility boilers.

Flue gas desulfurization (FGD) systems are installed on utility boilers primarily to control sulfur dioxide emissions although they also control particulate matter. These systems include an ESP or prescrubber, which removes fly ash from the flue gas, and an absorber, where the flue gases are then scrubbed or absorbed in a scrubbing solution. Sulfur dioxide reacts with the slurry in the scrubber-absorber and forms a sludge or a sulfur by-product. FGD processes are usually categorized as nonregenerable or regenerable. The nonregenerable process produces the sludge waste product that requires ponding or treatment to permit disposal in a land fill. Regenerable FGD processes recover sulfur dioxide from the combustion gases and convert it into marketable by-products such as sulfur, sulfuric acid, and liquid sulfur dioxide.

Nonregenerable FGD processes are better developed and more widely applied to utility boilers. They include lime or limestone scrubbing, the dilute or concentrated double alkali process, and scrubbing with sodium carbonate or sodium hydroxide solutions. These FGD systems can generally be designed to provide sulfur dioxide removal efficiencies of 80 to 95 percent under normal operating conditions.

Some of the regenerable processes have been demonstrated in systems of over 100 MW capacity but they are not in wide use. These processes include wet scrubbing systems such as the magnesium oxide, Wellman-Lord, and citric acid processes and a number of dry sorbent types, which do not require water quenching of the combustion gases. Sulfur dioxide removal efficiencies in excess of 90 percent have been demonstrated. Regenerable systems generally have a higher initial cost and operating expense than the nonregenerable processes and depend on credits from selling the by-product sulfur to partially offset the higher cost.

Burning low sulfur fuels is the other strategy commonly used to limit sulfur dioxide emissions. Low sulfur coal and oil may occur naturally, or the sulfur may be chemically or physically removed from the fuels. Refineries chemically treat oil with a hydrodesulfurization process to remove the sulfur. Sulfur may be physically separated from coal either at coal-cleaning plants or by the user. Because of the lower supply of naturally occurring low sulfur fuels, the cost of desulfurization, and the cost of transportation, the price of low sulfur fuels is higher than the price of other fuels in some regions. Boilers in the West do not incur a premium for low sulfur coals because low sulfur coals are mined in the western states.

Nitrogen Oxides Controls. The primary technique for controlling nitrogen oxides emissions from utility boilers and turbines is combustion modification. The objective is to reduce the peak flame temperature or the residence time at peak flame temperature in the combustion chamber. The modifications can achieve removal efficiency sufficient for the most stringent SIPs and for NSPS.

Boiler modifications include overfire air, flue gas recirculation, burners-out-of-service, and low NO_x burners. Most oil- and gas-fired units employ overfire air and flue gas recirculation. Some existing oil and gas-fired units modify combustion by alternately firing with some burners while leaving others out of service. Nitrogen oxides from existing coal-fired boilers are generally not controlled because these boilers are not subject to NO_x standards. New coal-fired boilers are designed with overfire air or low NO_x burners to comply with NSPS.

The wet techniques of water and steam injection are commonly used to control nitrogen oxides from utility gas turbines. Steam or water is injected directly into the combustion chamber or into the fuel or air prior to entering the combustion chamber.

Cost Methodology

Total compliance costs for electric utilities are presented in Table A3.1.1. Costs of compliance with particulate and sulfur dioxide standards were taken from a recent EPA study of the impact of environmental regulations on the electric utility industry by Temple, Barker, and Sloan, Inc. (TBS). These exogenous costs were disaggregated by type of fuel burned, age of unit, and type of control (equipment or burning low sulfur fuel).

Costs for nitrogen oxides control were estimated separately for boilers and gas turbines. Average costs per kilowatt of capacity were multiplied by affected capacity. The average cost figures were obtained from the EPA background document on the stationary gas turbine NSPS (EPA 450/2-77-017a) and recent estimates calculated for EPA by Acurex. Capacity information was taken from the TBS study and DOE data.

For estimating nitrogen oxides control costs, we assumed that units subject to SIPs will reach full compliance by 1990 and those subject to NSPS comply upon construction. For particulate and sulfur dioxide controls, the costs provided by TBS reflect historic compliance patterns up to 1979 and TBS projections of compliance through 1990.

Table A3.1.1. Fossil-Fuel-Fired Electric Plants

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE 1971: .236E+09

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2683.59	4669.06	5965.12	12904.59	25783.51
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1249.09	2069.92	2901.08	8316.66	25655.82
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	6173.03	18799.40	18050.72	37827.72	69575.62
TOTAL ANNUAL COSTS	7422.12	20869.31	20951.80	46144.38	95231.44

Chapter A3.2 Industrial and Commercial Boilers

This chapter covers the cost of compliance with particulate and sulfur dioxide standards in SIPs and NSPS by coal- and oil-fired industrial and commercial boilers. These boilers generate steam for space heat, electricity, and heat for industrial processes. Estimated costs include the costs of control equipment, which reduces particulate and sulfur dioxide emissions in the flue gas, and premiums paid for low sulfur fuel, which produces lower sulfur dioxide emissions during combustion.

Industry Characteristics

Commercial and industrial boilers constitute 99 percent of the nonresidential boiler population. Their capacity, however, is only 55 percent of total boiler capacity, the remainder being utility boilers. These boilers operate in a wide variety of commercial establishments and industries. Commercial boilers are generally smaller than industrial boilers, although there is considerable overlap in size. Industrial boilers, with a few exceptions, are smaller than utility boilers.

This section discusses the types of commercial and industrial establishments that use boilers, and the growth and size distribution, fuel use, and annual capacity utilization of boilers. Most of the data presented below are based on surveys of the boiler population in 1971 and 1977.

Usage. Commercial boilers are widely used in a variety of establishments. The smallest operate in apartment buildings, the largest in large institutions and hospitals. Others operate in schools, churches, small colleges, office buildings, and hotels.

Industrial boilers are used by almost all manufacturing industries. The chemical, petroleum refining, food, and paper industries are the major boiler operators. Other major industry groups using boilers include primary metals, textile mills, lumber and wood products, rubber, and transportation.

Growth and Size Distribution. The number of commercial and industrial boilers increased dramatically between 1971 and 1977. Commercial boilers quadrupled from 127 to 548 thousand, and industrial boilers tripled from 414 to 1,254 thousand. Because the growth was primarily due to an increase in the number of smaller boilers, however, capacity showed little or no growth from 1971 to 1977. Commercial boiler capacity in millions Btu per hour increased from 0.8 to 1.1 million, and industrial boiler capacity remained at 3.0 million.

In 1977, 97 percent of commercial and industrial boilers had a capacity of less than 10 million Btu per hour. Commercial boiler capacity is more concentrated in the lower size ranges than is industrial boiler capacity. Boilers with a capacity of less than 50 million Btu per hour equal 80 percent of total commercial boiler capacity. Less than 50 percent of industrial boiler capacity falls into this smaller size range. Only 5 percent of commercial boiler capacity has a capacity greater than 250 million Btu per hour; 25 percent of industrial boiler capacity is in this larger size class.

The increased price of fuel since 1979, and the subsequent lower growth in demand for energy, makes future growth in total boiler capacity unlikely. There is also no reason to expect the size distribution to change. Shifts in the use of fuel types are discussed below.

Fuel Use. Industrial and commercial boilers fire coal, residual and distillate oil, and gas. Although some boilers can be modified to fire more than one type of fuel, most are initially designed to fire only one type.

Between 1971 and 1977, the proportion of boiler capacity designed to fire each type of fuel did not change significantly. Coal-fired boilers represent approximately 20 percent of both commercial and industrial boiler capacity. Oil-fired boilers represent approximately 50 percent of commercial boiler capacity (the remaining 30 percent are gas-fired) and approximately 30 percent of industrial boiler capacity (the remaining 50 percent are gas-fired).

Department of Energy policies that discourage the use of natural gas or oil by major industrial users, along with relatively higher prices for these two fuels, are expected to result in a shift to coal for larger boilers. Although a few large residual oil-fired boilers are expected to switch to coal by design modification, most new large coal-fired units are replacements for retiring units. Large oil or gas-fired units were not ordered in the late 1970's and are not expected to be ordered in the future.

Smaller boilers firing gas and distillate oil are not expected to switch to coal even with the recent rise in prices of liquid fuels. Currently the premium paid for oil or gas is largely offset by the ease of operation and lower maintenance costs.

Annual Capacity Utilization. The percentage utilization of total annual fuel burning capacity in boilers is called the load factor. It is computed from annual capacity and fuel consumption data. The average load factor for industrial and commercial boilers is low, ranging from 0.1 to 0.5. This is a result of the large number of boilers on standby, either to be used during seasonal operations or in case of interruptions in the supply of purchased power.

Average load factors fell between 1971 and 1977. Although this may have been due to a different data base or methodology, it is also consistent with a decline in energy demand during the recession of 1977. If the recent slow growth in energy demand since 1979 continues, load factors are not likely to change.

Emission Sources and Pollutants

A boiler produces heat in the form of steam by fuel combustion. Liquids other than water can also be heated in the boiler for use in subsequent industrial processes and heating applications. The hot flue gases pass through a heat recovery section after producing steam in the boiler. They are then discharged through a stack.

Pollutants emitted by fossil-fuel combustion are a function of fuel composition, combustion efficiency, and combustion equipment design. Particulate emissions, which are in the form of smoke and fly ash (ash in the flue gas), are related to the ash content of the fuel and the combustion efficiency and design of the boiler. Sulfur oxide emissions, which are primarily in the form of sulfur dioxide, are a function of the sulfur content of the fuel. Sulfur dioxide emission rates do not depend on the type or size of furnace.

Nitrogen oxides are formed by the combination of oxygen (in the combustion air) and nitrogen. When combined with oxygen, nitrogen in the fuel forms organic NO_x and nitrogen in the combustion air forms thermal NO_x. Thermal nitrogen oxide emissions are a function of peak flame temperature and available oxygen, variables that depend on boiler size, firing configuration, and operating practices. Carbon monoxide and hydrocarbon emissions from all types of boilers are negligible.

Natural gas and distillate oil are considered clean fuels because of their low ash and sulfur content and their relative ease in burning at high efficiency. Coal and most residual oils contain significant amounts of sulfur and ash, require more sophisticated combustion equipment, and are more difficult to burn at high efficiencies.

This section discusses the operating characteristics and emission levels of coal-fired (both pulverized and stoker) and oil-fired boilers. Gas-fired boilers are not included because their primary emissions, nitrogen oxides, are relatively low and generally remain uncontrolled in commercial and industrial units. Only those pollutants with high emissions levels (particulates, sulfur oxides, and nitrogen oxides) are discussed.

Coal-Fired Boilers. Coal-fired boilers are of two primary designs: pulverized and stoker.

A pulverized unit fires coal that has been ground into small particles. Particulate emissions from pulverized boilers are lower for those with the wet bottom design than the dry bottom design. In a wet or slag bottom furnace, the temperature is maintained above the ash fusion temperature so that the ash is melted and can be removed from the furnace as a liquid or slag. Thus, as little as 50 percent of the ash is emitted in the flue gas. In a dry bottom furnace, the temperature is maintained below the ash fusion temperature so that the ash will not fuse. Nearly all the ash particles are formed in suspension, and about 80 percent of the ash leaves the furnace entrained in the flue gas.

A stoker-fired boiler uses stokers to feed coal onto a grate in the furnace and to remove the ash residue into a hopper for disposal. In stoker-fired units, the coal burning rate and the size of the coal affect the particulate emission level. In a properly operated stoker unit, the passage of air and the agitation of the fuel bed on the grate serve to keep ash accumulations porous. The ash is then discharged to an ashpit in fairly large pieces. Stokers are often preferred over pulverizers because of their greater operating range, their lower power requirements at higher rates of combustion, their capability to burn a variety of solid fuels, and their high efficiency and ease of combustion control.

In a coal-fired furnace, about 90 to 95 percent of sulfur in the coal is converted to sulfur dioxide. The balance of the sulfur is emitted in the fly ash or combined and removed with the slag or ash in the furnace. Nitrogen oxides emissions in coal-fired boilers are much smaller than particulate and sulfur oxides emissions.

Oil-Fired Boilers. Oil-fired boilers burn distillate and residual oil in suspension. Combustion of residual oil results in much higher levels of particulate and sulfur dioxide emissions than combustion of distillate oil. The significantly higher levels of ash in residual oil than distillate oil increase the particulate emission rate. In boilers firing residual oil, however, particulate emissions can be reduced by as much as 60 percent when boilers are fired at low loads.

In fuel oil combustion, essentially 100 percent of the sulfur content of the fuel is converted to sulfur dioxide. The sulfur content of residual fuel ranges from 0.5 to 2.0 percent, while that of distillate oil averages 0.25 percent.

Nitrogen oxides emissions from residual oil firing are primarily organic, formed from the nitrogen content of the fuel. Nitrogen oxide emissions from distillate oil firing are primarily thermal, formed from the nitrogen in the combustion air and dependent on the firing configuration.

Regulations

Federal air pollution standards cover newly constructed larger industrial boilers; state standards cover all sizes of industrial and commercial boilers. Both federal and state regulations set limits for particulate matter, sulfur dioxide, and nitrogen oxides.

NSPS. One NSPS governs the larger industrial boilers. The NSPS, which was promulgated December 23, 1971 (40 CFR 60.40), established limits for any boiler with a heat input rate of more than 250 million Btu per hour that commenced construction after August 17, 1971. A revised NSPS, promulgated June 11, 1979 (40 CFR 60.40a), which set more stringent limits for electric utility steam generating units that commence construction after September 19, 1978, does not cover industrial boilers.

The NSPS emission limits vary according to the type of fuel that is fired - solid, liquid, or gaseous. There is also currently under development a NSPS for industrial boilers with capacity between 10 and 250 million Btu per hour.

SIP. SIP emission limits for combustion sources govern industrial and commercial boilers. The regulations vary primarily according to size of source (heat input rate, expressed as million Btu per hour), age, fuel type, and geographic location (attainment or non-attainment area). States determine the heat input rate on either a design or actual basis and measure emissions by considering either all units of a facility, individual units, or individual stacks. In recent years, SIPs have become more specific in differentiating among boiler size, fuel type, and geographic location.

Particulate regulations are more stringent for larger boilers than for smaller boilers and for new sources than for existing sources. They are generally expressed as emission limits in pounds of particulate matter per million Btu heat input.

Sulfur dioxide regulations vary little by boiler size but do vary by fuel type. For those SIPs that differentiate among fuel types, the limits for residual oil are generally more stringent than those for coal. Most sulfur dioxide regulations for existing sources are designed to be met by burning low sulfur fuel rather than by installing controls for reducing flue gas emissions. They are generally expressed as emissions per unit heat input or per heat release potential (lb per million Btu), percent sulfur by weight in fuel, sulfur dioxide concentration in effluent gas, and mass rate of emissions per unit of time. A few SIPs require that the potential sulfur concentration in combustion gases be reduced by a specified percentage or require application of BACT control technology. These regulations implicitly prohibit compliance by burning low sulfur fuel.

Nitrogen oxides standards are included in only 16 SIPs. Because they primarily apply to combustion sources with a heat input rate of greater than 250 million Btu per hour, only the largest industrial boilers that are not also covered by NSPS are affected by these limits.

Control Technology

Particulate emissions from boilers can be controlled with low efficiency mechanical collectors or with high efficiency controls such as electrostatic precipitators (ESPs), fabric filters, and wet scrubbers. Sulfur dioxide control is achieved by flue gas desulfurization (FGD) systems or by burning low sulfur fuels. FGD systems are used for high efficiency particulate and sulfur dioxide emission control. Often, boilers that have control devices also burn low sulfur fuel to comply with regulations.

Each control method is discussed below, followed by our assumptions about boiler compliance. Because cost data are not available for nitrogen oxides control on the larger industrial boilers that are affected by the nitrogen oxides standards, these controls and costs are not included.

Mechanical Collectors. Mechanical collectors are capable of removing only larger particles. They do not achieve the level of particulate control efficiency required by the more stringent SIPs or by NSPS. Mechanical collectors are placed on most coal-fired boilers without the inducement of federal regulations. Recirculating the larger particulates into the furnace for further burning increases boiler efficiency, and even very lenient local air pollution regulations would not allow the emission of the larger particles that are captured by mechanical collectors. Therefore, we do not cost collectors. We assume that boilers with collectors that do not achieve standards will comply by installing more efficient particulate collection devices.

Electrostatic Precipitators and Fabric Filters. ESPs are the most widely used particulate control technology on pulverized coal- and residual oil-fired boilers. Fabric filters are being used increasingly on coal-fired stokers and to some extent on pulverized coal-fired units. Use of fabric filters is favored when sulfur content of the coal is very low and when carbon content of the particulate is high (as in spreader stokers).

Most ESPs and fabric filters that are installed on boilers are designed to achieve high removal efficiency: 97 to 99 percent for ESPs on coal-fired boilers, 78 percent for ESPs on residual oil-fired boilers, and 96 to 99 percent for fabric filters on coal-fired boilers. When properly operating, they achieve an efficiency level higher than that required by SIPs and the NSPS.

High efficiency (higher than would normally be considered necessary) controls are installed in order to prevent noncompliance during periods of faulty operation. These higher efficiency controls are also attractive because their cost is not significantly higher than a lower efficiency design. Therefore, ESP and fabric filter cost estimates for compliance with SIPs and both NSPS are based on the high efficiency design.

Flue Gas Desulfurization. Wet scrubbing FGD systems are installed on industrial boilers primarily to control sulfur dioxide emissions, although they also control particulate matter. These systems operate by putting flue gases in contact with a scrubbing solution after fly ash has been removed in an ESP or prescrubber. Sulfur dioxide reacts with the slurry in a scrubber-absorber and forms a sludge. The sludge is separated and disposed of, while the scrubbing solution is recirculated with the makeup slurry. Sulfur is discarded as waste with the sludge. These FDG systems can generally be designed to provide sulfur dioxide removal efficiencies of 80 to 95 percent under normal operating conditions. FGD systems are not widely used on industrial boilers, because boilers can comply with SIPs and NSPS by burning low sulfur fuels.

Most FGD systems applied to coal-fired industrial boilers in the United States employ the dual alkali process, although those installed on boilers in the pulp and paper industry scrub with sodium carbonate or sodium hydroxide solutions. Other types of systems include lime or limestone and ammonia scrubbing. The sodium systems are installed on oil-fired steam generators that are part of thermally induced oil recovery operations at oil drilling sites. Our cost estimates for FGD systems assume that dual alkali and sodium designs are installed on coal-fired units and that only the sodium design is installed on oil-fired units.

In costing FGD systems on larger coal-fired boilers, we assumed a particulate removal efficiency of 93 percent. This achieves both SIP and NSPS standards (emissions less than 0.10 lb per million Btu) for larger boilers. Our cost estimates for oil-fired boilers assumed FGD units with 78 percent particulate removal, resulting in emissions of about 0.05 lb per million Btu. This level is sufficient to meet SIP and NSPS standards.

We assumed a sulfur dioxide removal efficiency of 90 percent, which reduces emissions to a lower level (about 0.6 and 0.3 lb per million Btu for coal- and oil-fired boilers, respectively) than required by SIPs or the NSPS. This is a typical efficiency level for currently installed FGD units.

Low Sulfur Fuel. Low sulfur coal and oil may occur naturally, or the sulfur may be chemically or physically removed from the fuels. Refineries chemically treat oil with a hydrodesulfurization process to remove the sulfur. Sulfur may be physically separated from coal either at coal-cleaning plants or by the user. Because of the lower supply of naturally occurring low sulfur fuels, the cost of desulfurization, and the cost of transportation, the price of low sulfur fuels is higher than the price of other fuels in some regions. Boilers in the West do not incur a premium for low sulfur coals because low sulfur coals are mined in the western states.

We assumed the premium paid for low sulfur rather than high sulfur fuel is a cost of compliance. We defined low sulfur coal as having sulfur content less than 1.5 percent and low sulfur oil as having sulfur content less than 1.0 percent.

Compliance. We divided the boiler populations according to the type of control device currently installed, based on EPA compliance data reports. In our analysis, we assumed that only one type of control device is installed on each boiler and that the proportion of the boiler population installing each type will remain constant. The following compliance schedules for each segment of the boiler population were also derived from the EPA compliance reports.

Smaller (between 25 and 100 million Btu per hour) pulverized coal-fired boiler units that are to be equipped with ESPs or fabric filters are expected to comply with SIPs by 1985. The larger units were assumed to have complied by 1979. The smaller stoker coal-fired boiler units to be equipped with ESPs or fabric filters are expected to comply with SIPs by 1988. The larger units were assumed to have complied by 1981. The larger residual oil-fired boilers, which are equipped with ESPs, were assumed to have complied with SIPs by 1979. All larger boilers beginning operation after 1971 are assumed to comply with SIPs or NSPS upon construction.

Coal-fired boilers with FGD systems are expected to comply with SIPs by 1983. Residual oil-fired boilers with FGD systems were assumed to be in compliance by 1981. Boilers newly constructed after 1971 were assumed to comply with SIPs or NSPS upon operation.

Separately, we determined the amount of low sulfur coal and oil purchased at a premium by industrial and commercial boilers, most of which also have a control device. The fuel volume was based on analysis of EPA compliance data and the percent of boiler fuel consumed in states with SIP sulfur dioxide standards that require low sulfur fuel. Boilers that burn low sulfur coal at a premium were assumed to have complied with SIPs by 1980 and those that burn low sulfur oil, by 1975. New boilers (constructed after 1971) that burn low sulfur fuel were assumed to comply with either SIPs or NSPS immediately upon construction.

Cost Methodology

The total costs of controlling industrial and commercial boiler emissions are reported in Table A3.2.1. The costs of pollution control equipment -- ESPs, fabric filters, and FGD systems -- are estimated with cost equations. Costs are expressed as a function of boiler capacity in million Btu per hour. They were derived from two recent EPA documents that present detailed control costs for coal- and oil-fired industrial boilers (EPA Contract No. 68-02-3058 by Radian and EPA 450/5-80-007). The authors of these documents assumed an annual load factor of 0.4. FGD costs include sludge waste handling costs.

The cost of burning low sulfur coal and oil was estimated by applying a low sulfur premium to the amount of low sulfur fuel burned by industrial boilers. We estimated the low sulfur premium for industrial and commercial boilers using the price difference between low and high sulfur fuels paid by utilities.

Table A3.2.1. Industrial and Commercial Boilers

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .185E+10

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	252.01	3504.87	1058.71	2419.04	4191.65
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	186.80	776.69	542.05	1332.21	2944.39
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	438.80	4281.56	1600.76	3751.25	7136.04
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	742.71	2134.26	2107.96	4384.80	7271.39
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	214.62	463.14	553.66	1360.24	3413.02
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	957.33	2597.40	2661.62	5745.05	10684.42
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	1375.45	2325.40	3350.18	7423.70	12969.49
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	166.34	656.01	534.83	1022.13	2402.92
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1541.79	2981.41	3885.01	8445.83	15372.41
TOTAL ANNUAL COSTS	2499.12	5578.81	6546.63	14190.87	26056.83

Chapter A3.3 Natural Gas Processing Industry

Revision of this chapter included adjusting the pollution control costs to 1981 dollars and editing and updating the discussion of applicable regulations and industry characteristics.

Regulations

SIPs contain the primary regulations governing this industry, since there is no NSPS. The SIPs of the states where most sour natural gas production occurs have a wide variety of sulfur dioxide regulations governing gas processing plants. Most have requirements that are the equivalent to requiring 2- or 3- stage Claus plants on gas plants over a given size. This size varies from about 5 to 15 metric tons of total sulfur input per day, depending on the state, county, and location (rural versus urban). Florida has the most stringent rules, requiring tail-gas cleanup since 1975 and forbidding any flaring of hydrogen sulfide. Oklahoma requires tail-gas cleanup for all new plants; New Mexico requires it for new large plants (over 50 metric tons per day total sulfur input). In other states, tail-gas cleanup for large sulfur plants may be unofficially required for new permits, even though this is not spelled out in the regulations. Upgrading existing 2-stage Claus units to 3-stage units has been required to meet ambient or general emission standards in some areas. Sulfur dioxide standards are now also being established in the revised SIPs of other states with natural gas processing plants.

States with natural gas processing facilities have been recently encouraged by EPA to include volatile organic compound standards for these facilities in their revised SIPs. Prior to the 1981 release of a draft CTG document, few states included these regulations.

Although no NSPS have been proposed for this industry, NSPS are under development. The draft regulation would require control of volatile organic compound and sulfur dioxide emissions from new or modified facilities at natural gas/gasoline processing plants. The draft sulfur dioxide standard, which is expressed as a percentage efficiency requirement would in effect require a reduction in sulfur dioxide. The efficiency requirement would vary with plant size and have a lower size cut-off.

Industry Characteristics

The natural gas industry may be viewed as having three major sectors: exploration, production, and transmission-distribution. The exploration for and production of natural gas is usually associated with that of petroleum. The distinction between "oil wells" and "gas wells" is arbitrary--based on the ratio of oil to gas produced. Therefore, much of the exploration for natural gas is done by companies considered to be oil companies, most of them small. Natural gas is processed by the production sector for the most part, prior to entering transmission pipelines. The production sector is dominated by large firms, many of them primarily petroleum producers, but a large number of small firms contribute a sizable share of the total output. The transportation/distribution sector is primarily organized as public utility companies which operate under Federal and/or State regulations. These companies may get involved in processing when gas is retrieved from underground storage facilities. Although many gas-transmission companies are now integrating back into exploration and production, the basic structure of the industry remains as described here.

As of January 1, 1980, the 772 natural gas processing plants in the United States had a total capacity of 71.2 billion cubic feet per day. The average through-put rate of these plants in 1979 was 44.9 billion cubic feet per day. More than 65 percent of gas processing capacity and through-put is accounted for by plants located in Louisiana and Texas. From 1971 to 1978 the amount of total production and gas processed decreased an average of 2 percent per year. Total production has risen slightly since 1978 because of the incentives provided by the Natural Gas Policy Act of 1978 in deregulating the price of natural gas. All controls of natural gas prices are scheduled to be lifted by 1985.

Pollutants and Sources

Natural gas is primarily methane, but the raw gas contains varying amounts of heavier hydrocarbons and other gases such as carbon dioxide, nitrogen, helium, hydrogen sulfide and water vapor. To obtain a natural gas of pipeline quality, much of the content of these undesired components must be removed. The gas is normally purified at or near the well site in a natural gas processing plant. The heavier hydrocarbons which can be conveniently condensed are combined with the liquid (oil) production and sent to refineries for further processing or are sold as liquified petroleum gas (LPG) or petro-chemical feed stock.

Hydrogen sulfide and sulfur oxides derived from it are the air-pollution factors of greatest concern. Because of the corrosive, poisonous, and odorous nature of hydrogen sulfide, only very low concentrations are permitted in the natural gas product. Approximately 5 percent of the natural gas produced in the United States (so called sour gas) must be treated to remove hydrogen sulfide. The hydrogen sulfide content of raw natural gas varies from trace quantities to over 50 percent by volume. The high-concentration wells are operated more as sulfur sources than as natural gas wells.

It is in the disposal of the removed hydrogen sulfide that pollution occurs. Disposal can be by recovery of sulfur, or flaring, or venting. Although removal of the hydrogen sulfide from sour natural gas is universally practiced, recovery of the corresponding sulfur in elemental form to avoid air pollution is not universally practiced. In the large operations, Claus plants have been installed for this purpose, but in many small plants the hydrogen sulfide is merely flared, resulting in emissions of sulfur oxides. Venting is not acceptable because of the toxic nature of hydrogen sulfide.

For the natural gas plants which have Claus plants, the source of sulfur oxides emitted is the Claus plant tail gas, which is incinerated. The sulfur content of this emission corresponds to 4-6 percent of the sulfur originally fed to the Claus plant. For the natural gas plants without Claus plants, the sources of the sulfur oxides emitted are the flares in which the hydrogen sulfide that was removed from the gas is burned.

Emissions of hydrocarbons (from compressors) and nitrogen oxides are also matters of concern for new or modified plants due to the PSD and nonattainment regulations. These emissions are not analyzed in this chapter.

Control Technology

Because of the severe limitations on the hydrogen sulfide content of pipeline gas, all natural gas processing plants that handle sour gas already have amine-type scrubbing facilities or the equivalent to remove it from the raw gas. The technology needed to prevent hydrogen sulfide from causing air pollution consists of:

- A Claus sulfur plant in which most of the hydrogen sulfide is converted to elemental sulfur (94-96 percent cleanup)
- Treatment facilities to remove remaining sulfur compounds from the Claus plant tail gas (99-99.9 percent overall cleanup)

Costing Methodology

Cost data developed by EPA for refinery sulfur plants (EPA-230/3-76-004) were modified by changing the capital recovery figure and correcting for inflation. Since Claus plants larger than about 20 metric tons per day (22 short tons per day) produced a net credit when sulfur was valued at $43.5 (1979 $) per metric ton ($39.5 per short ton), only Claus units smaller than this are considered a cost. November, 1979 prices for crude sulfur ranged from $53 to $97 per metric ton ($88 to $48 per short ton), depending on quality factors and the location of the source relative to the Tampa market. The use of $43.5 reflects the probability that prices will drop as more sulfur recovery from flue gases come on line and as the sulfur content of imported crude oil rises.

Only three existing plants are estimated to have tail gas cleanup units.

Industry growth is hard to estimate in view of the slowly increasing capacity (1.5 percent per year, 1975-1979) and increasing output of sulfur units, 6.5 percent per year (1975-1978). In 1979, the 70 operating Claus plants in the natural gas processing industry had a total sulfur capacity of 2,187 thousand metric tons per year (2,410 thousand short tons per year), and an actual production rate of 1,753 thousand metric tons per year (1,932 thousand short tons per year). Apparently the existing plants are extending their coverage to gas plant output that was formerly flared. Future operating rates are estimated at 89 percent. It is assumed that new plants will be built annually amounting to 8 percent of existing capacity, i.e., the replacement of old with new as they wear out over a 16-year life plus an extra 2 percent for new fields and reservoirs remote from old plants. (This is the historic rate of addition of new reservoirs and fields.) The increment was distributed in various size plants in the same proportion as existing operating sulfur plants. The upgrading of Claus units from 2 to 3 stages probably involved 20-30 percent extra cost in constant dollars but was ignored because of lack of quantitative data and because much of this upgrading was done in the 1970-1972 period, before the SIPs were formalized.

The costs developed using the above approach are shown in Table A3.3.1. The NSPS costs reported in this table represent the cost to new plants of complying with more recent (post=1979) regulations enforced by states, not NSPS regulations.

Table A3.3.1. Natural gas processing industry

AIR POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP): .0	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	9.81	0.0	0.0	2.02
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.71	0.0	9.08	25.60	68.27
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	4.71	9.81	9.08	25.60	70.30
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	1.25	4.95	3.76	7.53	12.57
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.16	0.0	1.72	9.31	48.09
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.41	4.95	5.48	16.84	60.66
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	1.52	5.88	4.51	9.17	16.28
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.33	0.0	1.98	10.72	55.33
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.85	5.88	6.49	19.89	71.60
TOTAL ANNUAL COSTS	5.27	10.83	11.97	36.73	132.27

Chapter A3.4 Petroleum Refining

This chapter covers the cost of compliance with air pollution regulations by all stages of the petroleum refining industry including refining, storage and transfer. Table A3.4.1 lists the pollutants regulated at each source and the basis for the total industry costs reported in Table A3.4.2.

Industry Characteristics

The petroleum industry is often divided into extraction, refining, and transporting and marketing operations. Each market is dominated by the sixteen major oil companies, which are fully integrated into all stages of production. These sixteen companies produce about 70 percent of crude oil, operate about 70 percent of refinery capacity, and market about 70 percent of retail gasoline volume. There are, however, many smaller companies operating at only one stage, including several thousand in exploration and drilling, a few hundred in refining and a few hundred in retail marketing.

This chapter covers air emissions from refining processes, loading at distribution sites, and storage at the refinery and distribution sites.

Extraction of crude oil includes exploration, drilling oil wells, and extracting and pretreating the crude oil before storing or transporting it to refineries. Federal air regulations do not address emissions generated at this stage of production. Natural gas, which is also extracted from oil wells and produced and sold by oil companies, is covered in chapter 3.3.

Refining of crude oil into petroleum products comprises several processes. These include separation (distillation), conversion (e.g., cracking, reforming, alkylation, coking, visbreaking), treating (e.g., hydrotreating, chemical sweetening), and handling. Refining products include gasoline, distillate fuel oil (heating oil and diesel fuel), residual fuel, jet fuel, and liquid petroleum gas (LPG). Other products include kerosene, petrochemical feedstocks, coke, still gas, special naphthas, lubricants, and asphalts. The larger oil companies also manufacture petrochemicals; however, the petrochemicals industry is covered in chapter 5.2.

Operable refinery crude capacity in the United States in 1981 was 18.465 million barrels per day at 303 refineries, according to the annual refining survey of the Oil and Gas Journal. (The Department of Energy, on the other hand, reports 315 operating refineries in the United States and its territories with crude capacity of 18.051 million barrels per day.) The distribution of refineries by capacity size is reported by the National Petroleum Council in its 1979 refinery survey. Refineries with capacity

Table A3.4.1. Petroleum refining emissions sources, regulations and pollution control devices

Sources	Regulated Pollutant[a]	Control Devices
Refinery Catalytic Cracking Regenerator	Particulate matter	Electrostatic precipitator
	Carbon monoxide	Carbon monoxide boiler[b]
Refinery Fuel Gas Combustion Devices	Sulfur dioxide	Costs reported in Chapter A3.2
Sulfur Recovery Plants	Sulfur dioxide	Tail gas treatment
Miscellaneous Refinery Sources	VOC and fugitive benzene	Blowdown systems or incinerators[b]
Petroleum Storage Facilities:		
Crude oil and gasoline storage tanks	VOC	Floating roof
Jet fuel storage tanks	VOC	Floating roof[b]
Petroleum Transfer Facilities:		
Bulk storage terminals	VOC	Vapor recovery or incineration systems
Gasoline service stations	VOC	Vapor balance systems

[a] VOC = Volatile organic compound

[b] Costs for this device are not included in total costs for the industry (Table A3.4.2), because the value of recovered product exceeds the control cost, thereby yielding a net credit.

larger than 100,000 barrels per day constitute 65 percent of total refinery capacity but only about 20 percent of operating refineries. Refineries with a capacity less than 50,000 barrels per day constitute only 17 percent of total refinery capacity but 67 percent of total refineries.

Total refinery capacity grew at the average annual rate of 3.5 percent from 1971 to 1981. The annual rate increased from 3 percent during the year 1971 to 1976, to 4 percent during the years 1976 to 1981. Expansion of existing facilities and an increase in the number of small refineries were the main sources of growth in the past five years. Since 1974 more than 64 small refineries have been built, largely a result of the incentives provided by the federal small refineries entitlements program.

Capacity utilization during the 1970's remained relatively high (over 80 percent), reflecting stable demand growth for petroleum products. In 1980, however, capacity utilization began to fall and decreased to less than 65 percent in 1981. Decontrol of oil prices in 1980, which caused prices for refined products to rise, led to a severe decline in the demand for refined products by utilities and industrial and residential users and caused refinery shutdowns as well as the low capacity utilization in 1981. Capacity growth also declined and fell to 1.7 percent in 1981. Capacity for the remainder of the 1980's is not likely to increase, because oil demand is not expected to grow during the decade of the 1980's. This reflects both a switch to coal and a reduction in total energy demand.

Crude oil processed by refineries and gasoline production declined in 1980 and 1981. Although gasoline storage capacity rose from 246 to 275 million barrels between 1972 and 1977, it is not expected to increase by more than 1 percent per year in the 1980's given the falling demand. Naphtha jet fuel storage capacity has remained at 2.6 million barrels since 1971 and is also not likely to grow in the future.

Petroleum refineries are classified into SIC 2911: Petroleum Refining. The value of shipments for 1972 was $25.9 billion and for 1977, $91.7 billion.

Transporting and Marketing. Petroleum products are transported from refineries to a chain of distribution centers by pipeline, barge, ship, tank truck, or rail car. Bulk terminals are distribution and storage facilities having the capacity to distribute more than 475 barrels of product per day. They receive product from the the refinery by pipeline, barge, or ship, store it in above ground tanks, and dispense it into tank trucks or railcars. Bulk plants, which have a throughput of less than 475 barrels per day, are secondary distribution locations. Gasoline is transported by tank truck from bulk plants to gasoline service stations, the final distribution sites.

Bulk terminals and plants are concentrated primarily on the Atlantic Seaboard and in the North-Central States where the lack of refineries creates a reliance on imports from other regions and a demand for a larger distribution network. From 1972 to 1977, the number of bulk terminals remained at approximately 1900 and the total storage capacity increased only slightly, from 430 to 450 million barrels. Gasoline storage capacity rose from 155 to 166 million barrels, and naphtha jet fuel storage capacity has remained at 8.7 million barrels. During the same period, however, the number of bulk plants fell from 23,000 to 15,000, while their storage capacity remained at 70 million gallons. This decline in number and implicit increase in capacity per plant was partly the result of a reduction in the number of gasoline service stations. The number of gasoline service stations fell from 226,000 in 1972 to 154,000 in mid-1981. The annual rate of decline has been 5 percent since 1978 in response to the decline in gasoline demand.

Petroleum bulk terminals and plants, which are both classified into SIC 5171, reported sales for 1977 of $8.7 billion and $21.3 billion, respectively. Gasoline service stations, SIC 554, reported sales of $56.5 billion.

Emission Sources and Pollutants

This section describes the pollutants and sources listed in the regulations section, except for sulfur dioxide emissions from fuel gas combustion devices. Emissions from fuel gas combustion devices are discussed in Chapter 3.2 on industrial and commercial heating.

Catalytic Cracking Regenerators. Catalytic cracking is the principal refinery process for converting heavy oil to lighter, more marketable products, such as gasoline. During the cracking operation, a fraction of the heavy oil feed bonds to the catalyst in the form of coke deposits. These deposits impede the catalyst's ability to promote the cracking reactions; thus, a regenerator must regenerate the catalyst by burning off the coke deposits.

Three types of catalytic cracking units currently operate in U.S. refineries: fluid (FCC) and two types of moving units, Thermoflor (TCC) and Houdriflow (HCC). The following discussion addresses only FCC units because they constitute all new units and 95 percent of existing units, and because the continuous regeneration required in these units causes significant emissions.

The catalyst bed in an FCC is continually circulated between the reactor, where the coke is deposited on the catalyst, and the regenerator, where the coke is burned off. The amount of coke deposited on the catalyst per unit of feedstock is a function of the feedstock composition and other operating conditions. The major pollutants emitted from the FCC regenerator are carbon monoxide and particulates, in the form of catalyst fines, coke dust, and ash. If the feedstock is high in sulfur, release of sulfur dioxide in the flue gas can occur. Other pollutants include hydrocarbons, nitrogen oxides, ammonia, aldehydes, and cyanides. Only carbon monoxide and particulate emissions are significantly high to be regulated and therefore covered in this chapter.

Sulfur Recovery Plants. Claus sulfur recovery plants are operated by refineries to recover elemental sulfur from process gases. Sulfur recovery is the second stage of the desulfurizing "sweetening" process in which refineries reduce the sulfur content of high sulfur fuels. Most refineries use amine scrubbing units whose amine solution "scrubs" or absorbs hydrogen sulfide, the form in which sulfur occurs in the fuel gas. The hydrogen sulfide is either burned to sulfur dioxide through a flare or sent to a sulfur recovery plant.

Because of the profitability of recovering the elemental sulfur product, large refineries build Claus sulfur recovery plants. Control costs for sulfur dioxide emissions from the Claus plants are included in this chapter.

Miscellaneous Refinery Sources. Petroleum passes through several types of equipment during the various stages of the refinery. During the processing at each stage, fugitive VOCs are emitted. The primary sources of fugitive VOC emissions are (1) vacuum producing systems, (2) wastewater separators, (3) process unit turnarounds, and (4) miscellaneous equipment leaks.

The vacuum producing system, the first operation in a refinery, separates crude oil into its major constituents by distillation, stripping, and absorption. The steam ejectors (vacuum jets) on the vacuum distillation columns of the system are the primary source of noncondensible hydrocarbon emissions.

Wastewater separating systems treat the oily wastewaters from refineries. The API separator, the major unit, is a gravity settling device that causes oil to rise to the liquid surface and suspended solids to settle to the bottom so that they can be collected. Hydrocarbon emissions result from evaporation of volatile organic compounds from an uncovered surface.

Process unit turnaround refers to the shutdown, repair or inspection, or start-up of a process unit. Hydrocarbon vapors from turnarounds in all refinery process units are vented to a blowdown system, which is a set of relief devices, piping, or vessels. If uncontrolled, the blowdown system discharges significant levels of VOC emissions.

Sources of VOC leaks in refineries primarily include valves, flanges and other connecting devices, pump and compressor seals, drains, and pressure relief devices. If these sources are on vessels that contain petroleum liquids with benzene, then benzene emissions are also leaked.

Petroleum Storage. Petroleum storage facilities are located at refineries, along pipelines, and at distribution sites. The larger vessels, which are the majority of those regulated, are primarily at refineries and petroleum bulk terminals. The most significant hydrocarbon or VOC emissions occur from those vessels used to store crude oil, gasoline, and naphtha-type jet fuel. The magnitude of the emissions depends on the material in storage, climatic and meteorological conditions, and the type, size, and condition of the tank.

Petroleum Transfer Operations. Transfer facilities include bulk terminals, bulk plants, and service stations, as well as refinery loading platforms. VOC emissions occur during loading of storage tanks, barges, ships, tank trucks, and tank cars, as vapors are displaced from the empty tanks. Displaced vapors include vapors formed from evaporation of the residual product from a previous load, vapors generated from the newly loaded product, and vapors formed in the tank prior to removal of the previous load. The extent of hydrocarbon emissions that escape during loading depends on the physical and chemical characteristics of the previous and new cargo, the method of unloading and loading, and whether the tank was cleaned or purged between loads.

Regulations

Petroleum industry regulations cover emissions from refinery processes, sulfur recovery plants, refinery leaks, and petroleum storage and transfer at refineries and distribution sites.

In addition to the specific regulations described in the following paragraphs, petroleum refineries, sulfur recovery plants, and petroleum storage and transfer facilities (with a capacity exceeding 300,000 barrels) are on the list of major sources subject to BACT. Major new petroleum industry sources of all types sited in non-attainment areas are subject to LAER.

Refinery Catalytic Cracking Regenerators. Regulated pollutants from catalytic cracking regenerators include particulate matter and carbon monoxide; standards of performance are now under development for sulfur oxide emissions. NSPS (40 CFR 60.102 and 103), promulgated in 1974, cover particulate and carbon monoxide emissions from fluid catalytic cracking units.

SIPs generally cover all types of catalytic cracking regenerators. Particulate limits range from the NSPS level to less stringent limits. Most SIP carbon monoxide regulations are similar to the RACT standard suggested in Appendix B (40 CFR Part 41), which requires complete secondary combustion of waste gases.

Refinery Fuel Gas Combustion Devices. The 1978 NSPS for petroleum refineries (40 CFR 60.104) sets sulfur dioxide limits for fuel gas combustion devices except for fuel gases released to flare. The limit governs hydrogen sulfide in the gases.

SIPs cover both fuel gas combustion devices and process heaters. State combustion regulations that specify sulfur content in oil apply to the oil-fired boilers found in refineries. Most states require RACT standards for process heaters. Appendix B (40 CFR, Part 41) suggests a hydrogen sulfide limit from the process gas stream. Although these sulfur dioxide standards apply to combustion sources in refineries, the compliance costs are estimated in Chapter 3.2 on industrial and commercial heating, which covers combustion sources in all industries.

Sulfur Recovery Plants. The 1978 petroleum refinery NSPS (40 CFR 60.104) also covers sulfur dioxide emissions from sulfur recovery plants. The limit varies according to the type of control system. The majority of SIPs require the RACT standard in Appendix B.

Miscellaneous Refinery Sources. Fugitive emissions from miscellaneous refinery sources include benzene and VOC. These sources include vacuum producing systems, wastewater separators, process unit turnarounds, and miscellaneous equipment leaks. States with ozone non-attainment areas have adopted VOC regulations suggested by the control technique guideline documents released by EPA in 1977 and 1978. Rather than setting emissions limits, these SIP regulations specify control equipment such as incineration and vapor loss control devices. Approximately 85 percent of the refinery population is affected by these SIPs.

A National Emission Standard for Hazardous Air Pollutants (NESHAPS) covering benzene emissions was proposed on January 5, 1981 (46FR1165). It would regulate benzene emissions from all fugitive emission sources in refineries and chemical plants that process petroleum liquids with at least 10 percent benzene by weight. The standard would allow no detectable emissions from leaks in safety/relief valves and product accumulator vessels. It would also require a leak detection and repair program for pipeline valves and pumps and certain equipment for compressors, sampling connections, and open-ended valves. These controls are similar to those required by VOC regulations for SIPs. Because the NESHAPS covers only those petroleum refineries that produce benzene (a petrochemical feedstock), and because these refineries are located in states that regulate fugitive VOC emissions, the NESHAPS does not impose more stringent standards than SIPs.

Petroleum Storage Facilities. Two NSPS regulate VOC emissions from petroleum storage vessels with capacities exceeding 40,000 gallons. The 1974 NSPS (40 CFR 60.112) applies to vessels whose construction began between mid-1973 and mid-1978. The 1978 revised NSPS (40 CRF 60.112a) is more stringent and applies to vessels whose construction began after mid-1978. Both regulations specify control equipment for two ranges of storage pressure. The control equipment includes a vapor recovery system, floating roof and, for the 1978 NSPS, external floating roof with double seal.

SIP regulations, which are modeled after Appendix B (40 CFR Part 41, Appendix B) and EPA control technique guideline documents of 1977 and 1978, require control equipment similar to that of both NSPS.

Petroleum Transfer Facilities. The petroleum distribution/marketing system comprises a chain of loading sites, including bulk gasoline terminals, bulk gasoline plants, and gasoline service stations. A NSPS for bulk gasoline terminals, proposed December 17, 1980 (45 FR

83126), would require loading racks equipped with a vapor collection system.

SIP regulations specify control equipment (primarily vapor recovery) that is suggested in the EPA control technique guideline documents for the loading of tank trucks at bulk gasoline terminals, bulk gasoline plants, and gasoline stations. Because some states are in attainment for ozone and have no VOC regulations, only 70 percent of terminals and 90 percent of bulk plants and service stations are covered by SIPs.

Control Technology

Catalytic Cracking Regenerators. Particulate matter can be removed from the regenerator gas with two-stage internal cyclones and high efficiency electrostatic precipitators (ESPs). Two-stage internal cyclones are commonly installed in regeneration systems to improve the catalyst recovery efficiency. Since their installation is not motivated by environmental regulations, their costs are not included in this chapter.

We have assumed that ESPs meet the NSPS limit of 1.0 kg/1000 kg coke burn off and a SIP limit of 1.73 lb/1000 lb coke burn off, which is equivalent to the New York process weight standard of 95 lbs/hr. In 1971, about 31 percent of fluid catalytic cracker capacity was equipped with ESPs. Plants representing the remaining 69 percent of capacity without ESPs in 1971 were assumed to install ESPs at the rate of 16.7 percent per year from 1972 to 1978.

Carbon monoxide and unburned hydrocarbons in the flue gas of catalyst regenerators can be controlled by high temperature regeneration of the catalyst or by burning the flue gas in a carbon monoxide waste-heat boiler. High temperature regeneration causes a complete conversion of coke to carbon dioxide, thereby resulting in low levels of coke deposit on the catalyst and increasing catalyst activity. Because the increase in catalyst efficiency indicates economic motivation for utilizing high temperature regeneration and because sufficient cost information is unavailable, we have not included costs for this technique.

Waste-heat boilers provide significant thermal energy when reducing carbon monoxide emissions to levels required by NSPS or SIPs. We have assumed a control efficiency of 99.5 percent, which reduces carbon monoxide emissions to less than 50 ppm. Because the value of the steam generated from large carbon monoxide boilers outweighs the cost of the boiler, we assumed that these boilers are installed for economic reasons and yield a net credit to the industry. Therefore, no costs are recorded for carbon monoxide control in catalyst regenerators.

Sulfur Recovery Plants. Sulfur dioxide emissions from sulfur recovery plants can be controlled by three methods: (1) low temperature extended Claus reaction with tail gas treatment (IFP-1 or Sulfreen), (2) oxidation-scrubbing of the tail gas (IFP-2 or Wellman-Lord), and (3) reduction-scrubbing of the tail gas (Beavon, clean air, or SCOT). The first method achieves an average SIP standard of 99 percent recovery when retrofited to an incinerator. IFP-1 was chosen to represent this level of efficiency for costing SIP compliance. The second and third methods, represented by Wellman-Lord and Beavon, respectively, achieve 100 percent control, which meets the NSPS requirement of 97.9 percent recovery. We assumed that each method is installed in equal proportions on new sulfur recovery plants.

We assumed that sulfur recovery plants would only recover 95 percent sulfur without any air pollution control regulations. Plants operating in 1972 were assumed to comply with SIPs between 1972 and 1978. We also assumed that all plants beginning operation in 1972 through 1977 comply with SIPs, and those beginning after 1977 comply with NSPS.

The cost of the fuel-desulfurizing process (the amine units and the sulfur recovery plants) is reflected in a premium on the price of low sulfur fuel. This premium is incurred by fuel users, such as utilities and operators of industrial and commercial gas boilers, who use low sulfur fuel as a method of complying with sulfur dioxide standards for fuel gas combustion. Therefore, these costs do not appear in this chapter.

Miscellaneous Refinery Equipment. Noncondensable vapors vented from vacuum ejectors of vacuum systems can be controlled by venting the vapors through piping into blowdown systems or fuel gas systems and incinerating the collected vapors in furnaces, waste heat boilers, or incinerators. The recovered vapors yield enough energy when combusted that there is a net credit for the control.

A floating roof system for covering the forebays of wastewater separators is the preferred method of controlling the VOC emissions. Vapors from the fixed roof separator can also be vented to vapor recovery systems. Either method recovers product whose value outweighs the cost of the control system.

Control of vapor that is released from reactors during process unit turnarounds is similar to the techniques described above. The vapors, when vented to a blowdown system and incinerated, also yield a net credit for the investment.

The recommended control technique for VOC emissions from equipment leaks is a monitoring and maintenance program and, when necessary, a seal oil reservoir degassing vent control system. Given the increased price of gasoline in the past few years, the value of the recovered gasoline product is much greater than the total cost of both control techniques.

We assume that compliance with the SIP control requirements for miscellaneous refinery equipment is induced by the value of the recovered gasoline product. Therefore, no costs are reported.

Petroleum Storage. Crude oil, jet fuel, and gasoline are the primary fuel-related refinery materials whose storage requires a vapor pressure that is covered by VOC regulations. The 1974 NSPS and most SIPs require a vapor control system, a floating roof, or an equivalent system. Because of the value of recovered product, these control techniques are cost effective for crude oil and gasoline storage. There are, however, net costs for installing floating roofs on naphtha jet fuel storage tanks. Because of the colder climate, an incineration system, which does not recover product, is applied to facilities for crude oil and storage at Valdez, Alaska.

The 1980 revised NSPS for petroleum storage tanks and the California SIP differ from the 1974 NSPS and other SIPs in the regulation of tanks with a pressure of 1.5-11.1 psia (78-570 mm of mercury). These tanks must install an external floating roof with a double seal or equivalent. The additional product loss prevented by this more stringent control also results in a net credit on average. It is assumed that all crude oil and gasoline storage tanks beginning operation after 1970 and all existing tanks in California would comply because of the cost effectiveness of the control.

Petroleum Transfer Operations. VOC emissions during petroleum transfer can be controlled with three techniques: a controlled method of loading, a system for recovering or incinerating petroleum vapors, or a system for balancing displaced vapors. Controlled loading methods are used for loading at all types of distribution sites. Vapor recovery and incineration systems are currently installed only at gasoline bulk terminals, and vapor balance systems are used at gasoline bulk plants and gasoline service stations.

Splash loading is the uncontrolled method of filling a tank through an opening in the top of the tank. The splashing of gasoline as the gasoline falls to the surface of the liquid saturates with hydrocarbons the vapors that are vented through the opening. Two methods of controlled loading are available: submerged-fill and bottom loading. Submerged-fill loading reduces the splashing by loading the gasoline through a pipe that extends from the top opening to the bottom of the tank. Bottom loading reduces the splashing by pumping gas into the tank from an opening in the bottom of the tank.

A vapor recovery system collects VOC from the air-vapor mixture that is displaced during the transfer of gasoline. The air-vapor mixture may be treated and then held in a vapor holder tank before being piped into the processing units and tanks of the system. Systems in current use remove the VOC from the mixture with three different processes: refrigeration, compression/refrigeration/absorption, and carbon adsorption.

Refrigeration-type recovery units remove VOCs in a condensor by straight refrigeration at atmospheric pressure. In a compression/refrigeration/absorption system, the vapors are first saturated with gasoline and after storage in a vapor holder, they are compressed, cooled, and condensed. Uncondensed vapors are absorbed by chilled gasoline in a packed absorber column. The carbon adsorption vapor recovery unit uses beds of activated carbons to remove VOCs from the air-vapor mixture.

The most commonly used incineration system is the thermal oxidation unit. Instead of recovering gasoline, the unit relies on burning VOC vapors (using a pilot flame) to produce non-polluting combustion products.

The vapor balance or displacement system also recovers vapors. It operates by transferring vapors displaced from the receiving tank to the tank being unloaded. A vapor line between the truck and storage tanks creates a closed system that permits the vapor spaces of the two tanks to balance with each other.

EPA recommends all of these methods of control for adoption by states in their SIPs. We have assumed that the submerged-fill loading method is used at every loading rack and that bulk terminals install a vapor recovery system rather than incineration system where possible. (In colder climates, where vapors evaporate at a lower rate, the value of the recovered vapors may be so low that an incineration system is less costly.)

Each vapor recovery method is cost-effective because of the large volume of recovered gasoline and the recent high price of gasoline. We have assumed that, on average, bulk terminals do not incur a cost for VOC control, because the credit gained from installing vapor recovery units on some terminals outweighs the costs incurred with the incineration system on other terminals. Vapor balance systems are also profitable at bulk plants but not at gasoline service stations. Therefore, the only control costs for gasoline transfer reported in this chapter are those incurred by service stations.

Costing Methodology

Table A3.4.2 presents the total compliance costs for this industry. The cost methodology for each emission source is described below.

Catalytic Cracking Regenerators. Electrostatic precipitator cost estimates were developed from EPA cost engineering documents. Average costs for a model refinery were applied to capacity figures derived from historical capacity data, compliance assumptions, and forecast growth.

Costs and annual credits for steam generation were computed for a model carbon monoxide boiler. Because a net credit was obtained, no further computations were made.

Sulfur Recovery Plants. Costs for tail gas units were based on model plant costs and actual and projected capacity data. We subtracted the value of additional sulfur recovered from the tail gas. The total sulfur credit was based on actual sulfur prices for 1972-1981.

Miscellaneous Refinery Equipment. Control costs and product recovery credits for miscellaneous refinery equipment are reported in EPA control technique guideline documents. Because there is a net credit from operating the control systems, costs for these sources are not included in this report.

Petroleum Storage Facilities. We estimated the costs and product recovery credits associated with floating roof installation and a double seal on floating roofs for model crude oil and gasoline storage tanks. Since a net credit was produced, no costs are included in the chapter for these controls.

The incineration system on the storage tanks of the Trans-Alaska pipelines does not recover product; it is the only control for crude oil and gasoline storage that has a net cost. Also, control costs for naphtha jet fuel storage are reduced but not outweighed by product recovery credits. Costs for the Alaska storage tanks and net costs for the naphtha jet fuel tanks are reported in this chapter.

Petroleum Transfer Operations. We calculated costs and credits for two types of vapor recovery systems on model bulk terminals using current gasoline prices. EPA reported costs and credits for a vapor balance system on a model bulk plant. Because a net credit exists for each system, no costs are reported.

There are, however, net costs for a vapor balance system on gasoline service stations. These costs and credits were based on model plant costs and actual and forecast gasoline prices and industry data.

Table A3.4.2. Petroleum refining

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .441E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	113.71	666.69	298.97	499.30	691.19
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	128.66	252.49	344.67	781.45	1579.85
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	40.17	216.23	90.88	237.10	461.65
TOTAL ANNUAL COSTS	168.83	468.72	435.55	1018.55	2041.50

Chapter A3.5 Coal Cleaning

Revision of this chapter included adjusting pollution control costs to 1981 dollars, expanding the discussion of applicable regulations to include SIPs, and updating the discussion of industry characteristics.

Regulations

NSPS for coal preparation plants that process more than 200 tons/day of bituminous coal (40 CFR 60.250) were promulgated on January 15, 1976. The standards limit particulate emissions and plume opacity for thermal dryers and pneumatic coal cleaning equipment. They set opacity limits for processing and conveying equipment, storage systems, and transfer and loading systems.

SIPs regulate opacity and particulate emissions from coal cleaning facilities. Most of the SIP particulate regulations are patterned after process weight rate emission limits suggested in Appendix B (40 CFR 51, App. B) as standards achievable with RACT.

Industry Characteristics

This chapter covers the mechanical coal cleaning process and does not include desulfurization. Control costs are estimated for thermal drying plants, because the thermal drying process results in the greatest level of emissions from the coal cleaning industry.

Mechanical coal cleaning involves methods similar to those used in the ore-dressing industries. About 97 percent of coal cleaning is done by wet-processing methods, with pneumatic or air cleaning methods being used for the remainder. About 13 percent of the coal cleaned by wet-processing methods is thermally dried before being loaded. Coal is dried to avoid freezing problems, to facilitate handling, to improve quality, or to decrease transportation costs. In 1976, there were 114 thermal drying plants that processed a total of about 35 million short tons of coal. The annual quantity of thermally dried coal depends both on the amount of coal produced and the proportion of coal that is cleaned.

In 1980, the total production of bituminous and lignite coal in the United States was 780 million short tons from more than 6000 mines. The average annual rate of growth in production for 1971 through 1980 was about 4.5 percent. Production is expected to rise to 1.4 billion tons by 1990, representing an average annual growth rate of about 4 percent for 1980-1990. This increase is a result of the relatively higher prices of oil and gas since 1979, which induced the substitution of coal for oil and gas.

About 40 percent of the coal mined in this country is mechanically cleaned. The percentage declined slightly in the 1970's as a result of increased use of surface mining. Coal taken from surface mines contains fewer impurities than coal from underground mines and, therefore, requires less cleaning. The proportion of coal mined in surface mines (as opposed to underground mines) increased during the 1970's, largely because of the strict regulations of the 1969 Coal Mine Health and Safety Act. In the early 1970's, production was equally divided between underground and surface mining. By 1980, about 40 percent of the production came from underground mines and the remainder from surface mines.

The increased use of flue gas desulfurization (FGD) systems by utilities may increase future demand for mechanically cleaned coal. Although utilities that burn naturally-available low sulfur coal do not require cleaned coal, those that operate FGD systems demand clean coal for more efficient operation of the FGD systems. The revised NSPS for utility boilers (40 CFR 60.40a), which virtually requires the use of FGD systems to meet the sulfur dioxide standards (see Chapter A3.1), may provide incentive for utilities to use higher sulfur, deep-mined coal that would require cleaning. The percentage of coal that is cleaned may increase as a result. We assume, however, that the current percentage will not change substantially in the 1980's.

Pollutants and Sources

The emissions of primary concern from mechanical coal cleaning plants are the particulates resulting from drying operations. Data available indicated that 74 percent of the coal drying capacity was equipped with the devices capable of removing at least 99 percent of the particulate matter in the effluent gas. The remainder of the capacity was equipped with low-energy cyclones which remove only about 90 percent of the particulate matter. To meet environmental regulations, these cyclones will have to be replaced with the high-energy venturi scrubbers.

Control Technology and Costs

In most cases, the technology used for removing particulate matter will be venturi scrubbers. If other technology is used for some of the driers, its cost should be comparable to the cost of venturi scrubbers, thus a cost analysis based on venturi scrubbers should be valid.

A report, Background Information For Standards of Performance: Coal Preparation Plants gives some cost information on scrubbers for coal driers. This cost information was applied to the plant population of thermal driers to produce the aggregated costs of compliance. The costs shown in Table A3.5.1 reflect the costs for the previously uncontrolled fraction of the industry to comply with State Implementation Plans. Additionally, costs for new dryers subject to NSPS are shown, in agreement with information in the NSPS review (i.e., 17 new dryers since promulgation). This NSPS cost trend is extrapolated into the future years. The aggregated costs for compliance with both SIP and NSPS regulations are shown in Table A3.5.2.

Table A3.5-1. Control costs for coal cleaning - wet scrubbing equipment for thermal driers (in 1973 dollars)

Plant Size, Run of Mine	3,000,000 Short Tons/Year		5,000,000 Short Tons/Year	
Drier Feed*	401 Short Tons/Hour		668 Short Tons/Hour	
Drier Feed*	1,395,480 Short Tons/Year		2,324,640 Short Tons/Year	
Emission Standard	A State Regulation (0.07 gr/dscf)	Proposed U.S. Standard (0.03 gr/dscf)	A State Regulation (0.07 gr/dscf)	Proposed U.S. Standard (0.03 gr/dscf)
Control Investment**	$256,000	$284,000	$409,000	$454,000
Investment Increase Required		2.5%		2.8%
Annual Cost	$88,200	$118,200	$142,600	$192,300

*Based on 3480 hours/year and 46.5% feed to driers.

**Fabric filters for fugitive dust would add about $20,000 to each system and $5000 to annual costs.

Source: Background Information For Standards of Performance: Coal Preparation Plants Volume 1: Proposed Standards EPA450/2-74-02/a October 1974.

Table A3.5.2. Coal cleaning

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	44.12	0.0	0.0	0.05
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.77	7.49	5.14	10.81	22.75
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.77	51.62	5.14	10.81	22.80
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	5.80	31.44	17.40	34.81	43.24
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.66	2.89	4.29	10.75	28.32
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	7.46	34.33	21.69	45.55	71.56
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	4.31	23.35	12.92	25.84	17.27
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	5.21	9.06	13.45	33.70	89.27
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	9.51	32.41	26.38	59.55	106.54
TOTAL ANNUAL COSTS	16.97	66.74	48.07	105.10	178.10

Chapter A3.6 Coal Gasification

Revision of this chapter was limited to adjusting pollution control costs to 1981 dollars, general editing, and revising the discussion of regulations.

Industry Characteristics

Currently, no commercial coal gasification plants operate within the United States. Coal gasification is an emerging industry in which the first announced commercial plants will produce a high-Btu synthetic gas from coal to supplement domestic natural gas production.

Consumption of natural gas is constrained by the available supply. Dwindling reserves and the rising cost of natural gas are forcing consumers to seek alternative forms of energy such as coal, oil and electricity. Consumption of natural gas is expected to decline as a percent of total U.S. energy consumption. Synthetic gas from coal is one alternative source of natural gas which is anticipated to supplement domestic natural gas production.

Coal gasification is the combination of coal and water to form carbon monoxide, hydrogen, and some methane. Both pressure and elevated temperatures are required to promote the gasification reactions, which are many and varied. Thus, the key requirements for coal gasification are coal (carbon), water (steam), and heat.

Commercial coal gasification processes in use today outside the United States include the Lurgi, Koppers-Totzek, and Winkler processes, all for the manufacture of synthesis and fuel gases. Practically all of the first-generation coal gasification projects--those being engineered for the United States in commercial sizes today--are based on use of the Lurgi process. Three types of coal gasification plants have been proposed--low-Btu gasifiers for industrial and utility boiler fuels; intermediate-Btu gasifiers producing "synthesis" gas as feedstock for manufacture of liquid fuels, methanol, ammonia and possibly other valuable chemicals; high-Btu or substitute natural gas (SNG) to supplant declining natural gas supplies; and an intermediate-Btu gas for local use. For the low-Btu case, no commercial-sized plants exist; however, pilot-scale and demonstration plants are planned. Intermediate-Btu gas projects in the United States are also under consideration at this time, with no announced commercial plants.

High-Btu gas is well advanced with at least 22 plants under study. Because high-Btu gasification is nearest commercial production, and process and emission control schemes are unclear for the other cases, this report is directed toward high-Btu gas (SNG).

It is difficult to project the growth of the coal gasification industry. Uncertainties about world oil prices, coal and heater availability, and FPC decisions concerning incremental or roll-in pricing have already delayed the construction of the first proposed coal gasification plants. Government incentives, including loan guarantees and/or subsidies, could encourage more rapid development of coal gasification. For purposes of this report, it has been estimated that one plant will be constructed by 1986 and that the industry will grow at an annual rate of 20 percent from 1986 through 1990.

Emission Sources and Pollutants

As previously noted, the first-generation gasification processes are based on the Lurgi coal gasifier. In the Lurgi gasifier, gasification takes place in a countercurrent moving bed of coal at $2.07\text{-}2.76 \times 10^6$ N/m^2 (300-400 psig) and 540-760°C (1000-1400°F). A cyclic operation using a pressurized lock hopper is used to feed coal.

The pressurizing medium is a slip stream of raw gas which may later be repressurized and put back into the raw gas stream. The gasifier has a water jacket to protect the vessel and provide steam for gasification. Other features include blades to mechanically overcome caking, a moving grate on the bottom to remove dry ash, and a mechanism to introduce steam and air or oxygen uniformly over the gasifier.

Several high-Btu gas projects using the Lurgi coal gasifier have been announced and are at various stages of engineering. In addition to the gasification process itself, other major components include a large, 250-500 megawatt power boiler and steam superheater to provide steam for the gasification process; an oxygen plant which supplies oxygen to the gasifier; coal receiving, handling, storage, and preparation facilities; by-product recovery and storage, and waste-treating and -disposal facilities. The product gas has a typical heating value of 35-36 million joules per cubic meter (950-970 Btu per standard cubic foot) and consists of roughly 96 percent methane, 2 percent CO_2, 1 percent inert gas, and less than 1 percent mixture of hydrogen and carbon monoxide.

Lurgi coal gasification plants emit particulate matter, sulfur dioxide, nitrogen oxides, nonmethane hydrocarbons, and carbon monoxide. The steam generating facility is the primary point source that accounts for the bulk of the nitrogen oxides, particulate matter and sulfur dioxide emissions. The coal handling facility accounts for the remaining particulate matter emissions. The primary point sources of virtually all of the nonmethane hydrocarbon emissions, the remaining sulfur dioxide emissions (in the form of hydrogen sulfide), and carbon monoxide emissions are the coal gasifier lockhoppers, coal gas purification facilities, by-product recovery facilities, gas/liquor separation facilities, and the sour water stripping facilities.

Regulations

Because coal gasification is an infant industry, all plants are newly constructed and subject to standards governing new sources. Although no NSPS has been proposed for coal gasification plants, two promulgated NSPS cover emissions from selected sources in the plants. The NSPS for fossil-fuel-fired steam generators (40 CFR 60.40) covers particulate, sulfur dioxide, and nitrogen oxides emissions from the steam generating facilities. The NSPS for coal preparation plants (40 CFR 60.250) covers particulate emissions from the coal handling facility. For purposes of this report, it is expected that an NSPS will be proposed to regulate the remaining emission sources in this industry by the time the first plant has been constructed. This NSPS would regulate nonmethane hydrocarbons and hydrogen sulfide from the waste gas stream.

Only the New Mexico SIP has emission regulations specific to coal gasification plants. Other SIP regulations that would apply to these plants are general emission standards for particulates, sulfur dioxide, nitrogen oxides, and hydrocarbons.

Control Technology

The Lurgi coal gasification plants projected for construction in the United States by the domestic natural gas industry will employ the Lurgi Rectisol process to remove carbon dioxide and hydrogen sulfide from the coal gas. The Rectisol system is not considered an emission control system because sulfur removal is a process requirement of coal gasification.

Data and information developed by the domestic natural gas industry indicate that this process will discharge two waste gas streams. Depending on the properties of the coal gasified, the composition of one of the waste gas streams will be about 90-95 percent carbon dioxide, 0.5-1 percent nonmethane hydrocarbons, and 0.25-5 percent hydrogen sulfide; and the composition of the other waste gas stream will be about 55-95 percent carbon dioxide and 5-40 percent hydrogen sulfide.

Standards of performance for these emissions expected to be proposed by 1986 can not be based on existing plants because none exist. Therefore, emission control systems estimated for compliance with the expected NSPS covering these waste gas streams have been based on a "transfer-of-technology" from other industries.

The emission control technology demonstrated in the steel industry, the oil and natural gas production industry, the petroleum refining industry, and the carbon black manufacturing industry to control emissions of hydrogen sulfide and nonmethane hydrocarbons can be "transferred" to the coal gasification industry for application to Lurgi coal gasification plants. These control technologies include the use of Stretford and Claus sulfur recovery plants, tail-gas scrubbing to reduce sulfur emissions further, and incineration to reduce nonmethane hydrocarbon and carbon monoxide emissions. These control technologies will control about 98 percent of the sulfur compounds and nonmethane hydrocarbons.

Compliance with the steam generator NSPS is assumed to be achieved with an electrostatic precipitator and Wellman-Lord flue gas desulfurization system. It is assumed that fabric filters and water sprays are installed for compliance with the coal preparation plant NSPS.

Costing Methodology

The emission control capital costs under existing regulations range from $13.0 to $46.8 million for a 7 million cubic meter per day (250 million standard cubic feet per day) plant. These costs range from 1 to 6 percent of the anticipated capital costs of the coal gasification plant ($870 million). The cost variations result from variations in the sulfur content of the coal and the availability of water. The associated total annualized costs range from $18.8 to $28.7 million or 8 to 12 mills per cubic meter ($0.23 to $0.35 per thousand standard cubic feet).

The standards of performance expected to be proposed by 1986 would not increase the control costs over those of existing regulations for low-sulfur coal. The increase in installed capital costs to meet the proposed standards of performance for other coal would range from $1.7 to $3.3 million or 0.2 to 0.4 percent of the anticipated capital costs of a Lurgi plant. The associated total annual costs are $0.76 to $1.5 million or $0.35 to $0.70 per thousand cubic meters ($0.01 to $0.02 per thousand standard cubic feet). These are incremental costs of emission control above those to meet existing regulations.

The emission control stated above excludes estimated emission control costs associated with coal handling and steam generation. These installed costs range up to $29.0 million with annualized cost up to $7.4 million or 3 mill per cubic meter ($0.09 per thousand standard cubic feet) of product.

The total costs summarized in Table A3.6.1 are indicated for both SIP and NSPS regulations.

Table A3.6.1. Coal gasification

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	26.61
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	29.62
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	56.23
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	21.65
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	15.71
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	37.37
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	153.47
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	111.36
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	264.83
TOTAL ANNUAL COSTS	0.0	0.0	0.0	0.0	302.20

Chapter A3.7 Wood Waste Boilers

Revision of this chapter was limited to adjusting pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS (40 CFR 60.40) for fossil-fuel-fired steam generators cover those larger wood-waste boilers that are capable of burning fossil fuels at a heat input rate greater than 250 million Btu per hour. A NSPS for non-fossil fuel-fired boilers, a category that includes wood waste boilers with a heat input rate less than 250 million Btu per hour, is currently under development.

SIP regulations govern the smaller wood-waste boilers and larger boilers constructed prior to 1971. Most state regulations limit wood-waste boiler emissions under general emissions standards, which are patterned after suggested RACT standards for fuel burning (40 CFR 51, Appendix B). The limits for most states fall in the range from 0.1 to 0.6 lb per million Btu. Alaska and Florida have SIPs that distinguish wood-waste boilers from other types. The Florida SIP limits particulate emissions to 0.3 lb per million Btu from wood-waste boilers with heat input greater than 30 million Btu per hour.

Industry Characteristics

The burning of wood/bark waste in boilers is generally largely confined to those industries where it is available as a by-product. The wood/bark wastes are burned both to recover heat energy and to alleviate the potential solid waste problem. The fuel for a wood-waste boiler is generally wet bark and wood refuse originating from the debarking and cleanup of logs prior to shredding. A machine, called a hog, is used to reduce the size of the wood and bark materials to prepare them for firing in a boiler. A variety of furnace designs are used for wood-waste firing, such as Dutch ovens, spreader stokers, and suspension burners. For some of the larger operations, conventional boilers have been modified to burn wood-bark wastes. These latter units may include spreader stokers with travelling grates, vibrating grate stokers, as well as tangentially fired or cyclone-fired devices.

Heating values of hogged fuel range from about 8000 to 9000 Btu/lb on a dry basis. However, because representative moisture contents of 40 to 75 percent, the as-fired heating values for many wood-bark waste materials range from about 4000 to 6000 Btu/lb. Typical wood-waste boilers are 6 million Btu/ hr with larger units as high as 900 million Btu/hr. Most commonly, industrial wood-bark fired boilers have steam capacities of 20,000 to 150,000 lb/hr.

The estimated number of wood-waste boilers in 1979 was 500. Of these, it was estimated that 35 had capacities of 200,000 to 900,000 lb steam/hr. The remainder of the units ranged in capacities from about 5,000 to 180,000 lb steam/hr.

The growth rate for wood-waste boilers was assumed to be 4 percent per year from 1965 through 1979, and 3 percent per year for 1979 thereafter.

Pollutants and Sources

The major pollutant of concern from wood/bark waste boilers is particulate matter. Furnace design and operating conditions are particularly important for efficient burning of wood-bark wastes. In wood bark waste combustion, the primary pollutant is particulate matter from the entrainment of ash and sand in the combustion gases. Wood, unlike coal or oil, has a negligible quantity of sulfur and sulfur emissions are therefore very low, so that it was assumed that no SO_2 control would be needed for wood-waste boilers.

The emission factor for particulates from wood/bark waste boilers is 25 to 30 pounds per short ton of wood waste (50 percent moisture).

Control Technology

Various devices can be applied to wood-waste boilers to control particulate emissions. Generally, particulate removal efficiencies for various units are as follows:

Multitube Cyclones: 94-95 percent
Wet scrubbers: 98 percent
Electrostatic precipitators: 97-99 percent
Baghouse: 99.5 percent.

According to a 1976 study, one of the best available systems for handling particulates from wood-waste boilers is a multitube cyclone collector in series with a low energy impingement scrubber.

Costing Methodology

Control costs were estimated using the combination cyclone/scrubber unit. Equipped with a unit with a removal efficiency of 99.9 percent, boilers can readily meet the strictest emission regulations of 0.1 grain/SCF or 0.1 lb/10^6 Btu.

Pollution control costs for wood-waste burning were estimated using two sizes of model boilers (i.e., 300,000 and 55,000 lb steam/hr). The large 300,000 lb steam/hr boiler was representative of 35 boilers in 1979 with capacities of 200,000 to 900,000 lb steam/hr. The 55,000 lb steam/hr unit was representative of 465 boilers with capacities ranging from about 5,000 to 80,000 lb steam/hr.

The costs of control are given in Table A3.7.1 and were estimated for the following industry sectors and regulations:

Sector	Regulation
Small boilers	SIP
Large boilers	SIP and NSPS

Table A3.7.1. Wood waste boilers

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .554E+07

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	81.21	0.0	36.55	94.75
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.86	6.45	2.78	7.55	16.52
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.86	87.66	2.78	44.10	111.27
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	13.22	52.09	39.65	80.64	145.43
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.50	4.04	4.09	9.31	20.71
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	14.72	56.13	43.74	89.95	166.14
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	28.96	103.82	85.16	175.64	314.05
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.20	11.29	11.44	26.52	61.77
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	33.16	115.10	96.59	202.15	375.82
TOTAL ANNUAL COSTS	47.88	171.23	140.33	292.11	541.96

Chapter A4 Mobile Sources

Mobile sources costs have not been substantially revised. Changes in total costs primarily reflect updates of production data. Revisions to the chapter text include general editing and minor updates to the regulations.

Mobile sources are significant contributors to national air-quality problems. In areas subject to photochemical smog formation, over half the reactants can generally be attributed to motor-vehicle emissions. Similarly, motor-vehicle emission frequently cause large concentrations of carbon monoxide in high-traffic-density urban areas during traffic peaks. in cities with large and busy commercial airports, aircraft operations are often the principal source of high levels of carbon monoxide, hydrocarbons, nitrogen oxides, and particulates in the vicinity of the runways and terminals.

Light duty vehicles (automobiles) and light-duty trucks have been highly significant and visible pollutant sources because of the large numbers in service. Consequently, they have been under federal controls since the 1968 models. Federal emission standards for heavy-duty motor vehicles have been in effect since 1970, standards for aircraft emissions went into effect in 1974, and standards for motorcycles were imposed beginning with the 1978 model year. Evaporative emission standards and their control are not included in this chapter.

EPA began regulating lead content in gasoline in 1974. The costs associated with the lead phase-down requirements may logically be associated with either the petroleum refining industry or mobile sources. Lead phase-down costs have been included in this chapter so that the light duty vehicle emission control costs represent the total consumer cost of automobile emission regulations.

Other mobile sources, such as railroad locomotives, marine engines, and farm, construction, and garden equipment have been under study by EPA. Since no regulations for these sources have been promulgated or proposed, they are not included in this report.

This chapter is organized into three sections: regulations, control technology and cost methodology. The regulation and control technology sections are further subdivided by source category. The source categories are (1) light duty vehicles, (2) light duty trucks, (3) heavy duty vehicles, (4) motorcycles, (5) aircraft, and (6) gasoline.

Regulations

Light Duty Vehicles

Table A4.1 presents the emission standards for light duty vehicles. The standards are expressed in terms of maximum levels of gaseous emissions per unit distance permitted from the vehicle while operating on a prescribed duty cycle. Sampling procedures and test equipment are also prescribed by the regulations. The certification procedure requires that test cars meet emission standards after being driven over a prescribed durability schedule for 50,000 miles. For certain standards, waivers to less stringent levels are available on a case-by-case basis.

Accompanying the revisions in emission standards themselves have been changes in the Federal Test Procedure. These were implemented for the 1972 and 1975 model years.

The EPA Administrator suspended the 1975 statutory standards for carbon monoxide and hydrocarbons and the 1976 statutory standards for nitrogen oxides for one year. The suspension followed a determination that the effective control technology was not available. EPA established interim standards attainable with then existing emission control technology.

Federal standards prior to 1975 applied only to gasoline fueled vehicles. Those for 1975 and later model years apply to both gasoline and diesel fueled vehicles.

The Clean Air Act also allowed California to set more stringent standards for vehicles sold only in that state. California sets standards more stringent than federal standards for most model years. This chapter does not include costs for meeting California regulations.

Light Duty Trucks

Table A4.2 presents the emission standards for light duty trucks, which are expressed in the same terms as those for light duty vehicles. Before 1975, trucks weighing less than 6,000 pounds were subject to standards for light duty vehicles (automobiles), and trucks weighing more than 6,000 pounds were subject to standards for heavy duty gas engines. Beginning with the 1975 model year, EPA set standards for light duty trucks with an upper gross vehicle weight limit of 6,000 pounds. The light duty truck regulations covering the 1979 through 1983 model years increased the upper gross vehicle weight limits of 6,000 pounds. The light duty truck regulations covering the 1979 through 1983 model years increased the upper gross vehicle weight limit from 6,000 pounds to 8,500 pounds, made minor changes in test procedures, and increased the stringency of exhaust emission standards.

Table A4.1 New vehicle standards summary - passenger cars 1/
The following standards, up to 1975, apply only to gasoline-fueled light-duty vehicles.
Standards for 1975 and later apply to both gasoline-fueled and diesel light-duty vehicles.

Year	Test procedure 2/	Hydro- carbons	Carbon monoxide	Oxides of nitrogen	Diesel particulate	Evaporative hydrocarbon 3/
Prior to controls	7-mode	850 ppm	3.4%	1,000 ppm	-	-
	7-mode	11 g/mi	80 g/mi	4 gpm	-	-
	CVS-75	8.8 g/mi	87.0 g/mi	3.6 gpm	-	-
1968-69	7-mode					
	50-100 CID	410 ppm	2.3%	-	-	-
	101-140 CID	350 ppm	2.0%	-	-	-
	over 140 CID	275 ppm	1.5%	-	-	-
1970	7-mode	2.2 g/mi	23 g/mi	-	-	-
1971	7-mode	2.2 g/mi	23 g/mi	-	-	6 g/test 4/
1972	CVS-72	3.4 g/mi	39 g/mi	-	-	2 g/test
1973-74	CVS-72	3.4 g/mi	39 g/mi	3.0 g/mi	-	2 g/test
1975-76	CVS-75	1.5 g/mi	15 g/mi 5/	3.1 g/mi	-	2 g/test
1977 6/	CVS-75	1.5 g/mi	15 g/mi	2.0 g/mi	-	2.0 g/test
1978-79	CVS-75	1.5 g/mi	15 g/mi	2.0 g/mi	-	6.0 g/test
1980	CVS-75	0.41 g/mi	7.0 g/mi	2.0 g/mi	-	6.0 g/test
1981	CVS-75	0.41 g/mi	3.4 g/mi 7/	1.0 g/mi 8/, 9/	-	2.0 g/test
1982 10/	CVS-75	0.41 g/mi	3.4 g/mi 7/	1.0 g/mi 8/, 9/	0.60 g/mi	2.0 g/test
		(0.57)	(7.8)	(1.0) 8/	-	(2.6)

Continued....

Table A4.1 (Continued)

Year	Test procedure 2/	Hydro-carbons	Carbon monoxide	Oxides of nitrogen	Diesel particulate	Evaporative hydrocarbon 3/
1983 10/	CVS-75	0.41 g/mi	3.4 g/mi	1.0 g/mi 8/	0.60 g/mi	2.0 g/test
		(0.57)	(7.8)	(1.0) 8/	-	(2.6)
1984 11/	CVS-75	0.41 g/mi	3.4 g/mi	1.0 g/mi 8/	0.60 g/mi	2.0 g/test
1985 & later	CVS-75	0.41 g/mi	3.4 g/mi	1.0 g/mi	0.20 g/mi	2.0 g/test

corrected 12/1/81
corrected 5/5/82
revised 1/xx/83

Light-Duty Vehicles:

1/ Standards do not apply to vehicles with engines less than 50 CID from 1968 through 1974. Diesel particulate standards apply only to diesels.
2/ Different test procedures have been used since the early years of emission control which vary in stringency. The appearance that the standards were relaxed from 1971 to 1972 is incorrect. The 1972 standards are actually more stringent because of the greater stringency of the 1972 test procedure.
3/ Evaporative emissions determined by carbon trap method through 1977, SHED procedure beginning in 1978. Applies only to gasoline-fueled vehicles.
4/ Evaporative standard does not apply to off-road utility vehicles for 1971.
5/ Carbon monoxide standard for vehicles sold in the State of California is 9.0 gpm.
6/ Cars sold in specified high altitude counties required to meet standards at high altitude.
7/ Carbon monoxide standard can be waived to 7.0 gpm for 1981-82 by the EPA Administrator.
8/ Oxides of nitrogen standard can be waived to 1.5 gpm for innovative technology or diesel.
9/ Oxides of nitrogen standard can be waived to 2.0 gpm for American Motors Corporation.

Continued...

Table A4.1 (Continued)

10/ Standards in parentheses apply to vehicles sold in specified high altitude counties. Vehicles eligible for a carbon monoxide waiver for 7.0 gpm at low altitude are eligible for a waiver to 11 gpm at high altitude.

11/ These same numerical standards apply to vehicles sold in high-altitude areas.

g/mi - grams per mile
CID - cubic inch displacement
CVS-72 - constant volume sample cold start test
CVS-75 - constant volume sample test which includes cold and hot starts
7-mode - 137 second driving cycle test
ppm - parts per million

Table A4.2 New vehicle standards summary - light-duty trucks 1/
The following standards, for 1976, apply only to gasoline-fueled light-duty trucks.
Standards for 1976 and later apply to both gasoline-fueled and diesel light-duty trucks.

Year	Test procedure 2/	Hydro-carbons	Carbon monoxide	Oxides of nitrogen	Diesel particulate	Evaporative hydrocarbon 3/
Prior to controls	7-mode	850 ppm	3.4%	1,000 ppm	-	-
	7-mode	11 g/mi	80 g/mi	4 g/mi	-	-
	CVS-75	8.8 g/mi	87.0 g/mi	3.6 g/mi	-	-
1968-69	7-mode					
	50-100 CID	410 ppm	2.3%	-	-	-
	101-140 CID	350 ppm	2.0%	-	-	-
	over 140 CID	275 ppm	1.5%	-	-	-
1970	7-mode	2.2 g/mi	23 g/mi	-	-	-
1971	7-mode	2.2 g/mi	23 g/mi	-	-	6 g/test 4/
1972	CVS-72	3.4 g/mi	39 g/mi	-	-	2 g/test
1973-74	CVS-72	3.4 g/mi	39 g/mi	3.0 g/mi	-	2 g/test
1975-77 5/	CVS-75	2.0 g/mi	20 g/mi	3.1 g/mi	-	2 g/test
1978	CVS-75	2.0 g/mi	20 g/mi	3.1 g/mi	-	6.0 g/test
1979-80 6/	CVS-75	1.7 g/mi	18 g/mi	2.3 g/mi	-	6.0 g/test
1981	CVS-75	1.7 gpm	18 gpm	2.3 gpm	-	2.0 g/test
1982-83 7/	CVS-75	1.7 gpm	18 gpm	2.3 gpm	0.60 gpm	2.0 g/test
		(2.0)	(26)	(2.3)	-	(2.6)

Continued...

Table A4.2 (Continued)

Year	Test procedure 2/	Hydro-carbons	Carbon monoxide	Oxides of nitrogen	Diesel particulate	Evaporative hydrocarbon 3/
1984 7/	CVS-75	0.80 gpm	10 gpm	2.3 gpm	0.60 gpm	2.0 g/test
		(1.0)	(14)	(2.3)	-	(2.6)
1985 & later 7/	CVS-75	0.80 gpm	10 gpm	2.3 gpm	0.26 gpm	2.0 g/test
		(1.0)	(14)	(2.3)	-	(2.6)

10/8/80
corrected 5/5/82
revised 1/12/83

Light-Duty Trucks:

1/ Standards do not apply to vehicles with engines less than 50 CID from 1968 through 1974. Diesel particulate standards apply only to diesels.

2/ Different test procedures have been used since the early years of emission control which vary in stringency. The appearance that the standards were relaxed from 1971 to 1972 is incorrect. The 1972 standards are actually more stringent because of the greater stringency of the 1972 test procedure.

3/ Evaporative emissions determined by carbon trap method through 1977, SHED procedure beginning in 1978. Applies only to gasoline-fueled vehicles.

4/ Evaporative standard does not apply to off-road utility vehicles for 1971.

5/ Cars sold in specified high altitude counties required to meet standards at high altitude (1977 only).

6/ Effective in 1979, light-duty truck classification was extended from 0-6000 pounds GVWR to 0-8500 pounds GVWR.

7/ Standards in parentheses apply to vehicles sold in specified high altitude counties.

Continued....

Table A4.2 (Continued)

Additional Requirements:

A CO standard of 0.47% at idle is established for 1984 and later model years.

gpm - grams per mile
CID - cubic inch displacement
CVS-72 - constant volume sample cold start test
CVS-75 - constant volume sample test which includes cold and hot starts
7-mode - 137 second driving cycle test
ppm - parts per million
GVWR - gross vehicle weight rating

Heavy Duty Vehicles

Separate emission control regulations have been in effect since 1970 for new heavy duty gasoline and diesel truck engines manufactured for use in over-the-highway trucks and buses. These standards apply to trucks with a minimum gross vehicle weight of 6,000 pounds for 1978 and earlier model years and a minimum of 8,500 pounds for model years after 1978. Heavy duty truck engine certification test procedures are performed on the engine itself and do not pertain to the vehicle, as is the case for light duty truck and light duty vehicle (automobile) regulations.

Federal emission standards for heavy duty gasoline engines are presented in Table A4.3 and for heavy duty diesel engines in Table A4.4. The regulations covering 1970 through 1973 model year heavy duty gasoline engines set hydrocarbon and carbon monoxide emission standards. The 1973 heavy duty diesel engine standards covered smoke emissions only. Regulations for 1974 and later model years added standards for carbon monoxide and hydrocarbon emissions for heavy duty diesel engines and set either nitrogen oxides or hydrocarbon plus nitrogen oxides emission standards for both gasoline and diesel engines. All of these standards are expressed in terms of grams per unit work, i.e., grams per brake horsepower per hour (bhp/h).

The pre-1979 model year heavy duty gasoline engine standards measured emissions in terms of average concentrations in the engine exhaust over a nine mode, constant speed, variable load dynamometer cycle. The pre-1979 test procedure for diesels was different: emissions were averaged over a 13 mode, variable speed, variable load dynamometer cycle. The 1979 through 1983 regulations for both gasoline and diesel engines changed both test procedures and test instrumentation.

The 1977 Clean Air Act Amendments required that EPA prescribe (for heavy duty engines and vehicles) emission standards requiring at least a 90 percent reduction for hydrocarbons and carbon monoxide from uncontrolled levels beginning with the 1984 model year, unless certain findings are made. A new test procedure based on a transient driving schedule representative of on-road operation is being considered.

Motorcycle

EPA promulgated both the interim (1978-1979) and longer term emission standards (1980 and later) for motorcycles in 1977. The standards, which do not apply to motorcycles with engine displacements of less than 50 cubic centimeters (cc), prohibit crankcase emissions and set limits on gaseous emissions.

Motorcycle gaseous emission standards are summarized in Table A4.5. The interim hydrocarbon exhaust emission standard varies with engine displacement: from 50.0 g/km (8.1 g/mi) for motorcycles with up to 170 cc displacement and increasing proportionately with displacement up to 14.0 g/km (22.6 g/mi) for motorcycles with displacement of 750 cc and greater. Hydrocarbon standards for 1980 and later model years and carbon monoxide

Table A4.3 New vehicle standards summary - heavy-duty engines and vehicles
(gasoline-fueled)
The following is a summary of gasoline-fueled heavy-duty engine and vehicle standards 1/

Year	Hydrocarbons	Carbon monoxide	Oxides of nitrogen	Hydrocarbons and oxides of nitrogen	Evaporative hydrocarbons
Prior to Control 2/	9.7 g/BHP-hr	121 g/BHP-hr			
	12.7 g/BHP-hr	155 g/BHP-hr			
1970-73	275 ppm	1.5%	-	-	-
1974-78	-	40 g/BHP-hr	-	16 g/BHP-hr	-
1979 3/, 4/	1.5 g/BHP-hr	25 g/BHP-hr	-	10 g/BHP-hr	-
	1.0 g/BHP-hr	25 g/BHP-hr	-	9.5 g/BHP-hr	-
	-	25 g/BHP-hr	-	5 g/BHP-hr	-
1980-83 3/	1.5 g/BHP-hr	25 g/BHP-hr	-	10 g/BHP-hr	-
	-	25 g/BHP-hr	-	5 g/BHP-hr	-
1984 5/	(A)1.5 g/BHP-hr	25 g/BHP-hr	-	10 g/BHP-hr	-
	-	25 g/BHP-hr	-	5 g/BHP-hr	-
	(B)1.3 g/BHP-hr	15.5 g/BHP-hr	10.7 g/BHP-hr	-	-
1985 & later 6/	1.3 g/BHP-hr	15.5 g/BHP-hr	10.7 g/BHP-hr	-	3.0/4.0 g/test

10/8/80
revised 1/12/83

Continued.....

Table A4.3 (Continued)

Gasoline-Fueled Heavy-Duty Engines and Vehicles:

1/ Test procedure for 1970-1983 standards is the 9-mode steady-state test procedure. Test procedure for 1984 is either steady-state or transient test. For 1985 and later, the transient test procedure is used.

2/ The first set of numbers represents uncontrolled emissions as measured on the 9-mode steady state test procedure, the second set represents uncontrolled emissions as measured on the transient test procedure.

3/ Optional standards.

4/ Standards of 1.0 HC, 25 CO, and 9.5 NOX may be used if old test procedure with NDIR HC measurement method is used.

5/ At the manufacturers' option, the 1983 standards and test procedure may be used (option A) or standards of 1.3 HC, 15.5 CO, and 10.7 NOX with the transient test procedure (option B).

6/ Evaporative standards are 3.0 g/test for trucks between 8,500 and 14,000 lbs GVWR; 4.0 g/test for those over 14,000 lbs. GVWR.

Additional Requirements:

A CO standard of 0.47% at idle is established for 1984 and later model years (applies only to option b for 1984).

5/BHP-hr - grams per brake horsepower - hours
ppm - parts per million
g/test - grams per test
9-mode - gasoline engine dynamometer test with 9 steady-state test points
transient - engine dynamometer procedure with stops, starts and speed/load changes.
GVWR - gross vehicle weight rating

Table A4.4 New vehicle standards summary - heavy-duty engines and vehicles (diesel)

The following is a summary of diesel heavy-duty engine and vehicle standards 1/

Year	Hydrocarbons	Carbon monoxide	Oxides of nitrogen	Hydrocarbons & oxides of nitrogen	Particulates	Smoke (opacity)
1970-73	-	-	-	-	-	ACCEL 40% LUG 20%
1974-78	-	40 g/BHP-hr	-	16 g/BHP-hr	-	ACCEL 20% LUG 15% PEAK 50%
1979-83	1.5 g/BHP-hr -	25 g/BHP-hr 25 g/BHP-hr	- -	10 g/BHP-hr 5 g/BHP-hr	- -	ACCEL 20% LUG 15% PEAK 50%
1984 2/	(A)1.5 g/BHP-hr -	25 g/BHP-hr 25 g/BHP-hr	- -	10 g/BHP-hr 5 g/BHP-hr	- -	ACCEL 20% LUG 15% PEAK 50%
	(B)1.3 g/BHP-hr 0.5 g/BHP-hr	15.5 g/BHP-hr 15.5 g/BHP-hr	10.7 g/BHP-hr 9.0 g/BHP-hr	- -	- -	ACCEL 20% LUG 15% PEAK 50%
1985 & later	1.3 g/BHP-hr	15.5 g/BHP-hr	10.7 g/BPH-hr	- -	- -	ACCEL 20% LUG 15% PEAK 50%

10/8/80
revised 1/12/83

Continued...

Table A4.4 (Continued)

Diesel Heavy-Duty Engines and Vehicles:

1/ Test procedure for 1970-1983 standards is the 13-mode steady-state test procedure. Test procedure for 1984 is either steady-state or the transient test procedure. For 1985 and later, the transient test procedure is used.

2/ At the manufacturers' option, either the 1983 standards and test procedures may be used (option A), or standards of 1.3 HC, 15.5 CO, and 10.7 NOx on the transient test procedure (option B). Also, standards of 0.5 HC, 15.5 CO, and 9.0 NOx are optional standards for 1984 diesels tested on the 13-mode test procedure.

g/BHP-hr - grams per brake horsepower - hour
ppm - parts per million
13-mode - diesel engine dynamometer test with 13 steady-state test points
transient - engine dynamometer procedure with starts, stops, and speed/load changes

Table A4.5 New vehicle standards summary - motorcycles 1/
The following is a summary of motorcycle standards adopted by the
Environmental Protection Agency

Year	Displacement 2/	Hydrocarbons	Carbon monoxide
Prior to Controls 3/	All (average)	5.6 g/km	21.5 g/km
1978-79	50-169	5.0 g/km	17 g/km
	170-749	5.0 + 0.0155(D-170)	17 g/km g/km 4/
	750 & larger	14 g/km	17 g/km
1980 & later	All (50 & larger)	5.0 g/km	12 g/km

1/ A motorcycle is any motor vehicle with a headlight, taillight, and stoplight, and having: two wheels or three wheels and a curb mass less than or equal to 680 kilograms (1499 pounds).

2/ Displacement shown in cubic centimeters

3/ Uncontrolled Emissions:

		Hydrocarbons	Carbon monoxide
2-stroke	range	7.0-13.8 g/km	12.5-21.0 g/km
	average	9.6 g/km	16.8 g/km
4-stroke	range	1.0-2.1 g/km	11.0-31.0 g/km
	average	1.8 g/km	26.1 g/km

4/ Motorcycle Hydrocarbon Formula
D = engine displacement in cubic centimeters
e.g., 300 cc engine;
standard = (300-170) X .0155 + 5.0 = 7.0 g/km

g/km - grams per kilometer

4/28/82

standards for 1978 and later model years do not vary with size of engine. No standard for nitrogen oxides has been promulgated, because the motorcycle contribution to motor vehicle nitrogen oxides emissions is negligible, estimated to be less than one-half percent in 1990.

Aircraft

Table A4.6 presents the aircraft emission standards. The regulations, which cover various new and in-use aircraft engines, are based on the need to control emissions occurring under 900 meters (3,000 feet) to protect ambient air quality in urban areas. They reflect emission levels judged by EPA to be practicable with present and projected technology. The regulations include fuel venting restrictions beginning in 1974, smoke emission standards beginning in 1974, 1976, 1978, and 1981 for various engine classes, and gaseous emission standards (carbon monoxide, hydrocarbon, and nitrogen oxides) beginning in 1981 and 1982. Gaseous emission regulations are based on a simulated landing and take off operating cycle that includes taxi/idle (out), takeoff, climb out, approach, and taxi/idle (in). Piston engines were included in the standards beginning in 1980 but have since been deleted.

In August 1976, EPA promulgated regulations limiting emissions from currently certified SST aircraft manufactured after January 1, 1980, and more stringent emission standards for SST aircraft that are newly certified after January 1, 1984. In March 1978, EPA extended the compliance date for gaseous emission standards from January 1, 1979, to January 1, 1983, for most engines except piston aircraft.

In late 1982, EPA issued standards for new and in-use aircraft gas turbine engines with the exception of those used for general aviation aircraft. These most recent standards set new limits on hydrocarbon emission, eliminated carbon monoxide and nitrogen oxides standards, and designated new engine classes.

Gasoline

EPA regulations governing lead content in gasoline directly affect fuel costs for light duty vehicles. Gasoline marketers were required to make available 91 research octane number lead-free gasoline by July 1, 1974, for use in oxidation catalyst-equipped vehicles. Another regulation required that the lead content of the total gasoline pool be reduced to an average of 0.13 gram per liter (0.5 gram per gallon) by October 1980 for large refiners and by October 1982 for small refiners. In October 1982, EPA promulgated a new lead content regulation that limited lead content to 1.1 grams per gallon (gpg) for leaded gasoline only. The 1.1 gpg "lead only" standard is intended to be equivalent (in terms of total lead usage) to the existing 0.5 gpg standard in the near term and to accelerate the removal of lead from gasoline thereafter.

Lead phase-down requirements advanced the need for installation of new octane-generating capacity compared to the requirement that would naturally result from the gradual replacement of vehicles that use leaded gasolines by vehicles that use unleaded gasoline.

Control Technology

Light Duty Vehicles

1968-1974 Model Years. From 1968 to 1974, compliance with federal emission standards was achieved by utilizing various combinations of the following:

- Purging crankcase fumes through the engine
- Recalibration and tighter precision in carburetor fuel metering
- Engine intake air preheat and temperature control
- Spark retard at idle and low speeds
- Reduced compression ratios and eliminating combustion chamber pockets
- Air injection into the exhaust manifold
- Changes in value timing and recirculating exhaust gas
- Capturing fuel evaporative emission in charcoal canisters or in the crankcase.

1975-1976 Model Years. When the 1975 statutory standards were suspended for a year and replaced with less stringent interim standards, it became apparent that two types of emission-control systems could be used for the 1975 model year: (1) oxidation catalyst-equipped systems, and (2) advanced engine modifications systems. The oxidation catalyst systems were preferred by the industry, and approximately 85 percent of the 1975 model year sales included catalysts. Other changes and additions for some 1975 model-year cars included:

- Quick-heat manifold
- High-energy ignition
- Advanced carburetors
- Air injection.

Because the 1976 emission standards called for the same hydrocarbon, carbon monoxide, and nitrogen oxide levels as the 1975 interim standards, only minor changes in emission control systems were made from 1975 models. Proportional exhaust gas recirculation was introduced in some models.

1977-1979 Model Years. Automobile companies met the 1977 standards with only minor modifications to engines and control devices. These modifications took the form of increased use of secondary air for catalyst operation, improved exhaust gas recirculation, and ignition timing modification or modified catalysts with decreased use of secondary air.

1980 Model Year. 1980 standards required addition of a modified catalyst, and electronic control modules for the following items: spark control, exhaust-gas recirculation, air-to-fuel ratio, and air injection.

1981 and Subsequent Model Years. In addition to the modifications in the prior model years, 1981 standards required a three-way (HC, CO, NO_x) catalyst system plus a downstream oxidation catalyst on some models.

Light Duty Trucks

The emission control technology used in light duty trucks is similar to that in light duty vehicles.

Heavy Duty Vehicles

The emission control technology used for heavy duty gasoline engines through 1973 is similar to that employed for light duty trucks and light duty vehicles through the 1972 model year. Many heavy duty gasoline engines are derivatives of light duty vehicle engines. For 1974, the nitrogen oxide control standards were generally attainable without the use of exhaust gas recirculation (EGR), which was required for light duty trucks and vehicles. However, some engines with EGR were certified to meet the 1973 California standards, which are the same as 1974 federal standards.

Most heavy duty diesel engines have achieved both smoke and gaseous emission standards, including those for 1974, with fuel-injection system modifications. Carbon monoxide standards are easily attainable by most diesel engines; even uncontrolled diesels are usually well within carbon monoxide standards.

Aircraft

Aircraft met the 1974 - 1975 fuel venting restrictions by plumbing and/or operational changes and the 1974 smoke standards by combustor and fuel nozzle retrofit. The 1976 through 1980 smoke and gaseous emission standards required no additional hardware for compliance. The 1981 and 1982 gaseous emission standards were met with a modified engine hot section. 1983 and later model year standards are expected to require advanced combustor and engine concepts.

Cost Methodology

Table A4.6 presents the total cost of mobile source pollution control. Capital expenditures for mobile source air pollution controls represent the costs of pollution control hardware requirements for automobiles, five weight classes of trucks (less than 6,000 pounds, 6,000-8,500 pounds, 8,500-10,000 pounds, gasoline trucks over 10,000 pounds, and diesel trucks over 10,000 pounds), motorcycles, and aircraft. For all except aircraft, these costs were calculated by multiplying an average cost per vehicle by the annual production (actual historical and forecast) of that vehicle type. Historical production results were taken from an MVMA report and earlier EPA studies. Future production figures were based on forecasts in Automotive News and projections by DRI. Per vehicle cost estimates were based on previous EPA studies.

Costs for light duty trucks and heavy duty vehicles are primarily based on cost estimates for light duty vehicles. Cost estimates for aircraft controls were based on the economic impact assessment prepared for a recent relaxation of the aircraft emission control standards. The most recent standards for which costs per vehicle were estimated are the 1979 model year light duty trucks and heavy duty vehicles, the 1980 and later model year motorcycles, and the 1981 and later model year automobiles and aircraft engines.

O&M expenditures for mobile sources were developed based on estimates of the average impact of emission controls on maintenance cost, fuel economy, and fuel cost (due to requirements for unleaded fuel) in each model year. A simple model that takes into account the stock of various model year vehicles in each year, numbers of miles driven per year by age, and average fuel economy was employed.

Emission controls may result in either an increases or a reduction in maintenance costs. Emission controls that generate a net reduction in maintenance costs include high-energy ignition systems, long-life exhaust systems, the use of catalysts, and unleaded fuel. The net emissions-related maintenance costs are estimated to be either negative or zero for most model years.

EPA has estimated that the application of some control techniques reduces fuel economy. Although there is much controversy over the issue, the costs in this chapter include the penalties and benefits of fuel economy effects originally estimated by EPA. Fuel economy penalties are estimated for pre-1976 model year light duty vehicles and trucks and pre-1983 model year heavy duty vehicles. Fuel economy benefits are estimated for post-1975 model year light duty vehicles and trucks. It is difficult to estimate fuel economy benefits associated with 1977 and later model year vehicles, because manufacturers are required to meet corporate average fuel economy (CAFE) standards mandated by the Energy Policy and Conservation Act of December 1975.

The cost of lead phase-down requirements was incorporated into the total unleaded gas price penalty incurred by owners of automobiles that require unleaded gasoline. This gas price penalty also includes the cost of additional pumps at service stations.

Chapter A4.6. Mobile sources

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	4581.41	22803.54	13649.57	28654.07	58978.92
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	4792.64	10798.72	12563.73	30718.96	77802.97
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1254.69	44299.91	5243.11	7073.31	2751.51
TOTAL ANNUAL COSTS	6047.33	55098.63	17806.84	37792.27	80554.48

Chapter A5. Chemicals Industries

For the purposes of this report, the Chemicals Industries are defined as those establishments which manufacture products primarily by chemical modifications of raw materials and for which the final product is a chemical.

Those included are the:

- Petrochemicals Industry
- Vinyl Chloride
- Nitric Acid Industry
- Sulfuric Acid Industry
- Phosphate Fertilizer Industry
- Nonfertilizer Phosphorus Chemicals
- Mercury-Cell Chlor-Alkali Industry
- Ammonia and Urea
- Ammonium Nitrate Fertilizers

Costs for the abatement of air pollution for these industries are summarized in Table A5. These costs and other data are repeated below in the appropriate section together with the assumptions specific to the industrial sector and other details.

TABLE A 5. CHEMICAL
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 5. 1	PETROCHEMICALS	11.41	31.82	37.94	70.54	127.83
A 5. 2	VINYL CHLORIDE	14.02	111.27	223.38	268.98	169.07
A 5. 3	NITRIC ACID	0.41	48.32	18.42	21.00	63.09
A 5. 4	SULFURIC ACID	19.76	570.10	128.89	212.65	719.79
A 5. 5	PHOSPHATE FERTILIZER	6.62	114.21	18.16	42.16	170.10
A 5. 6	NONFERTILIZER PHOSPHATES	0.20	9.95	0.60	1.22	6.02
A 5. 7	MERCURY-CELL CHLOR-ALKALI	0.0	18.81	0.0	0.0	14.14
A 5. 8	AMMONIA & UREA	5.62	12.56	15.27	22.90	16.39
A 5. 9	AMMONIUM NITRATE FERTILIZERS	0.11	0.10	0.28	0.43	0.27
	TOTAL INVESTMENT	58.14	917.15	442.93	639.88	1286.70

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 5. 1	PETROCHEMICALS	11.90	9.03	30.13	78.91	182.35
A 5. 2	VINYL CHLORIDE	96.34	51.37	269.65	588.07	1203.20
A 5. 3	NITRIC ACID	25.27	42.67	75.13	152.30	260.24
A 5. 4	SULFURIC ACID	298.02	769.72	837.80	1749.02	2802.32
A 5. 5	PHOSPHATE FERTILIZER	29.26	110.01	85.31	179.09	348.42
A 5. 6	NONFERTILIZER PHOSPHATES	1.77	4.93	5.20	10.75	19.64
A 5. 7	MERCURY-CELL CHLOR-ALKALI	7.77	27.96	23.65	50.81	96.98
A 5. 8	AMMONIA & UREA	5.91	6.47	14.19	36.97	75.66
A 5. 9	AMMONIUM NITRATE FERTILIZERS	0.13	0.06	0.29	0.84	1.70
	TOTAL ANNUAL COSTS	476.36	1022.22	1341.34	2846.77	4990.48

Chapter A5.1 Petrochemicals Industry

This chapter contains emissions control cost estimates for the following six large-volume petrochemicals that are manufactured by oxidation processes:

- Formaldehyde
- Acrylonitrile
- Ethylene Oxide
- Ethylbenzene/Styrene
- Maleic Anhydride
- Dimethyl Terephthalate/Terephthalic Acid

There are many other petrochemicals. These six chemicals were selected for inclusion because EPA projected both their 1982 production and potential uncontrolled emissions of regulated pollutants to be high.

Industry Description

There is no hard and fast definition that clearly separates petrochemicals from all other segments of the organic (containing carbon) chemical industry. In general, petrochemicals are relatively simple organic chemicals that are manufactured from the primary organic chemicals derived from cracking and distillation of petroleum. However, some of the same "petrochemicals" may be produced from primary chemicals derived from coal-tar or natural gas.

The six chemicals considered in this chapter are also products of the synthetic organic chemical manufacturing industry (SOCMI). SOCMI chemicals ultimately yield synthetic products: fibers, plastics, dyes and synthetic rubber. The NSPS for VOC fugitive emissions lists several hundred SOCMI chemicals in addition to those discussed in this chapter. The six chemicals included in this chapter are also chemicals that can be produced by air oxidation processes. In fact, 100 percent of acrylonitrile, formaldehyde, DMT, and TPA production is via air oxidation. About 18 percent of styrene and 50 percent of ethylene oxide are synthesized in this manner. The apparent trend is that emission of criteria pollutants from the individual petrochemical manufacturing industries will be regulated by generic standards that apply to broad categories such as SOCMI.

From 1967 until the 1975 recession, the organic chemical industry was growing at an annual rate of 8.5 percent. A growth of 5.9 percent per year is forecast for the 1980's. The trend to petroleum feedstocks has changed the organic chemical industry in two ways. It has attracted most of the major petroleum refiners into the chemical industry, and major chemical companies have acquired or merged with oil companies. The potential decontrol of oil and natural gas is making coal-based feedstocks more attractive again.

About 46 percent of the plants discussed in this chapter are located in the states of Texas and Louisiana. Ohio, New Jersey, and North Carolina each contain about seven percent, and the remainder are sprinkled throughout the country, mainly in the southeast.

Model plant sizes used as the basis for the cost estimates in this chapter are shown in Table A5.1.1 along with the number of plants represented by each size category. A discussion of specific industries follows. The four-digit SIC codes to which each chemical is assigned are shown with the headings below.

Formaldehyde (SIC 2869). Formaldehyde is synthesized by oxidation of methanol with air and is sold as an aqueous solution (usually 37 percent by weight). About 75 percent of the domestic formaldehyde production used the silver catalyst process and the other 25 percent used the metal oxide process in 1980.

The industry is characterized by a large number (53) of relatively small plants. Since more than half the formaldehyde is ultimately used for wood products, the producing plants are located mainly in the South and Northwest. Because most formaldehyde is shipped as a solution containing 50 percent or more water, shipping costs are relatively high. Thus, formaldehyde plants tend to be located near consumption points where possible.

Production in 1980 was 5,693 million pounds of 37 percent formaldehyde. The manufacture of adhesive for particle board and plywood constitutes 60 percent of formaldehyde end uses. Plastics (primarily used in automobiles and appliances) account for about 15 percent more. Formaldehyde is also an intermediate in many polymers and derivatives.

There is evidence that urea/formaldehyde foam insulation and particle board may emit toxic gases. Research is now underway on this problem; its impact on future control requirements is not yet clear. However, the Consumer Product Safety Commission banned the use of urea/formaldehyde foam insulation in February 1982.

Formaldehyde production is expected to grow at a rate of about five percent per year through 1990. This growth rate assumes improvement in the demand for materials used for residential construction (for new units and/or expansion and repair of existing units).

Acrylonitrile (SIC 2869). Domestic acrylonitrile is produced by four companies at six locations. Each plant employs a process involving the catalytic ammoxidation of propylene. Other methods have been used in the past and a pilot plant has been built to produce acrylonitrile from propane.

The average annual growth rate for acrylonitrile production was 5.8 percent from 1970 through 1980 and 8.5 percent from 1975 through 1980. Production in 1980 was 1,830 million pounds. Growth was due primarily to increased demand for acrylic fibers in the apparel and home furnishings

Table A5.1.1 Plant sizes for selected petrochemicals

Product/Process	Number of plant sites	Million pounds per year Plant size Range	 Average	 EPA Model Plant Size
Formaldehyde				
Silver Catalyst	24	60- 195	101	100
	10	200-1500	406	
Metal Oxide Catalyst	11	45- 117	83	100
	8	120- 250	155	
Acrylonitrile	6	265- 440	358	397
Ethylene Oxide				
Air Oxidation	6	99-1274	728	500
Oxygen Oxidation	9	99- 701	283	300
Styrene	8	80- 600	344	661
	5	900-1500	1230	
Maleic Anhydride				
Benzene	7	26- 84	50	50
Butane	2	21- 60	37	--
DMT/TPA				
DMT from crude - TPA	2	500- 550	517	593 1/
	2	1250-1344	1297	
TPA	3	240-2000	1080	---

1/ This is a crude TPA plant.

Sources: 1980 Directory of Chemical Producers United States, pp. 60, 61, 64, 241-2, 581-2, 587-8, 557-8, 822-3, 933.

1981 Directory of Chemical Producers United States, pp. 49, 51, 53, 56.

EPA-450/3-80-028d. IT Enviroscience, Inc. Organic Chemical Manufacturing Volume 9: Selected Processes, "Formaldehyde," "Ethylene Oxide," December 1980, p. IV-1.

EPA-450/3-80-028a. IT Enviroscience, Inc. Organic Chemical Manufacturing Volume 6: Selected Processes, "Maleic Anhydride," "Ethylbenzene/Styrene," December 1980, p. IV-1.

EPA-450/3-80-028e. IT Enviroscience, Inc. Organic Chemical Manufacturing Volume 10: Selected Processes, "Acrylonitrile," December 1980, p. IV-1.

EPA-450/3-80-028b. IT Enviroscience, Inc. Organic Chemical Manufacturing Volume 7: Selected Processes, "Crude Terephthalic Acid, Dimethyl Terephthalate, and Purified Terephthalic Acid," December 1980, p. IV-1.

industries. Acrylic fibers accounted for 67 percent of acrylonitrile production in 1977. Exports accounted for 22 percent of production in 1980 and were expected to increase in 1981. Acrylonitrile's derivative acrylonitrile-butadiene-styrene (ABS) copolymer is used in packaging and, along with styrene-acrylonitrile polymer (SAN), had an annual growth rate of eight percent from 1977 through 1980. However, because acrylonitrile is still considered a potent carcinogen by the FDA, additional regulations concerning its use may appear soon and slow its growth rate. A 5.9 percent annual growth rate may be estimated through the 1980's, based on the expected growth for SOCMI.

Ethylene Oxide (SIC 2869). Ethylene oxide is produced by the direct oxidation of ethylene, with either air or oxygen used as the oxidant and with a silver catalyst.

There were 12 producers in 1981 and a total of 15 plants. Production in 1980 was 5,300 million pounds. Ethylene oxide's growth is dependent on the automobile and polyester industries. Ethylene glycol, which is used in anti-freeze and polyester fibers and films consumed 60 percent of 1980 production. Ethylene oxide production grew at an annual rate of 3.9 percent from 1975 through 1980, and an EPA-suggested growth rate of about five percent per year from 1978 through 1983 could continue through the 1980's.

Ethylene oxide is considered a health hazard by the Occupational Safety and Health Administration (OSHA) and by the Food and Drug Administration (FDA). Its use as a sterilant or fumigant may be further regulated.

Ethylbenzene/Styrene (SIC 2865). Ethylbenzene and styrene are being considered together because practically all (99 percent) ethylbenzene is used as an intermediate in styrene production, often in the same plant. There are 14 companies producing ethylbenzene in 17 plants. Styrene is produced by 10 companies in 13 plants.

The primary process for domestic ethylbenzene production is by benzene alkylation with ethylene. Except for one plant using the Oxirane process, all domestic styrene is produced by the catalytic dehydrogenation of ethylbenzene. Future plants' use of the Oxirane process will depend on the economics of both the styrene and the propylene oxide that are coproduced by this process.

Production of ethylbenzene was 7,611 million pounds in 1980. Production of styrene in 1980 was 6,904 million pounds. Demand for styrene (and, therefore, for ethylbenzene) has recently been reduced by the severely depressed housing and auto markets. Eighty percent of styrene production goes into polymers that yield plastics and resins for both markets. Another 10 percent of production goes toward styrene-butadiene rubber for tires. Exports account for the remainder. The industry could have a growth rate of five percent per year through the 1980's after recovery from the recession of the early 1980's.

Maleic Anhydride (SIC 2865). Approximately 73 percent of domestic maleic anhydride is produced by the oxidation of benzene. Twenty-five percent is produced by the oxidation of n-butane and the remainder (at one small plant) is derived as a by-product of phthalic anhydride production. Although the proposed benzene NESHAPs would require using the n-butane process in new maleic anhydride plants, manufacturers would select this process anyway because lower feedstock costs make it more economical. We assume in this report that all maleic anhydride production capacity now using the benzene oxidation process will continue to do so.

There are presently eight companies producing maleic anhydride at eight locations. One plant uses both the n-butane and benzene processes; it is treated as two separate facilities in the plant inventory in Table A5.1.1. A 130 million pound facility is due on-stream in 1983. Production in 1980 was 298 million pounds. Approximately 52 percent of maleic anhydride production is consumed in the manufacture of the unsaturated polyester resins that go into glass-fiber-reinforced plastics for the auto and construction industries. Annual growth projections in the six to seven percent range are now suggested for maleic anhydride.

Dimethyl Terephthalate/Terephthalic Acid (DMT/TPA) (SIC 2860). DMT and TPA are alternative raw materials for the production of polyester products. One gram of purified TPA can be substituted for 1.17 grams of DMT. Both DMT and purified TPA are produced from crude TPA. Crude TPA is synthesized by air oxidation of p-xylene in the presence of acetic acid.

Production in 1980 was 5,995 million pounds. Polyester fiber accounts for 80 percent of production, films account for eight percent, polyethylene terephthalate (PET) barrier resins for soft drink bottles account for about eight percent, and other forms and exports account for the rest. PET barrier resins are the fastest growing use for DMT/TPA at this time.

This industry exhibited an average annual growth rate of 30 percent from 1966 to 1976, making it the fastest growing of all the major intermediate petrochemicals during that period. Industry sources project annual growth for the 1980's between three and eight percent.

Emission Sources and Pollutants

The major air pollution problem in the petrochemicals industry is the emission of VOCs and carbon monoxide via off-gases produced in oxidation processes. The petrochemicals creating this problem include not only oxygen-containing compounds, such as oxides, aldehydes, and anhydrides, but also compounds in which oxygen serves an intermediate role in the synthesis, such as acrylonitrile.

A typical process of this type begins with the raw material, air (sometimes oxygen), and sometimes a third reactant being fed into a vaporphase catalytic oxidation reactor. The reactor effluent gases go to an absorber in which the desired product is scrubbed out. The off-gas from this absorber, which is vented to the atmosphere, is primarily nitrogen and carbon dioxide, but smaller amounts of carbon monoxide and unconverted hydrocarbons are also present. The emission sources and pollutants are discussed below for each of the six petrochemicals.

Formaldehyde. Two processes are currently used to produce formaldehyde: silver catalyst and metal oxide. In both processes methanol is converted into formaldehyde by mixing with air.

The primary source of VOC emissions in both processes is the product absorber vent. The product fractionator vent is also a major source in the silver catalyst process. Smaller amounts of emissions occur from storage and handling of methanol and formaldehyde, and fugitive VOCs are potentially emitted from process pumps, valves, and circulating cooling water. VOC emissions are in the form of unreacted methanol, methanol vapors, formaldehyde, methyl formate, methylal, and water vapor.

Acrylonitrile - SOHIO Process. The absorber vent gas is the largest source of emissions; it contains nitrogen, oxygen, propane, propylene, acrylonitrile, hydrogen cyanide, acetonitrile, other organics, and some water vapor. The composition of the vent gas depends on such factors as the catalyst, reactor conditions, and propylene purity. Propylene and propane account for approximately 90 percent of the VOCs emitted.

The column vents are the next largest emissions source. Emissions also result from the storage and handling of acrylonitrile and by-product and intermediate streams. Fugitive emissions from process pumps, compressors, and valves account for approximately 11 percent of uncontrolled emissions.

Ethylene Oxide - Air Oxidation Process. The main process vent emits 89 percent of VOC emissions in the form of nitrogen, unreacted oxygen, ethane, unreacted ethylene, ethylene oxide and CO_2. The overhead stream from the stripper column is vented through a stripper purge vent which emits six percent of total VOC emissions.

Fugitive emissions come from pumps, compressors, valves, and also from the process water from the desorbers. Emissions also result from the storage and handling of ethylene oxide.

Primary emissions from the oxygen oxidation process of ethylene oxide production are generated by a CO_2 purge vent and an argon purge vent. Controls have not been required on the CO_2 purge vent because of the extraordinarily high cost. Control of the argon purge vent is estimated to be insignificant.

Styrene. The primary reactions in the production of styrene are catalytic alkylation of benzene with ethylene to produce ethylbenzene and catalytic dehydrogenation of ethylbenzene to produce styrene. This process emits VOCs in the form of benzene, ethylbenzene, styrene, ethane, ethylene, and methane. About 60 percent of these process VOC emissions is in the form of benzene.

Seventy-two percent of the benzene emissions is from the process itself, including 62 percent from the column vents, and 21 percent is from storage and handling. Seventy-five percent of the VOC emissions is from the process (56 percent from the column vents and 19 percent from the alkylation reaction section), 14 percent is from storage and handling, and 11 percent is fugitive.

Maleic Anhydride. Ninety-seven percent of the VOCs and benzene emitted comes from process emissions. The product-recovery scrubber vent gas containing CO, benzene, and other VOCs is the major source of air pollutants. At most maleic anhydride plants, emissions from some or all of the storage tanks are vented directly to the atmosphere. These emissions include benzene, maleic anhydride and xylene. Process pumps and valves are a potential source of fugitive emissions.

The n-butane process does not use benzene so there are no benzene emissions. There are no public data on this process yet, but other VOC emissions are believed to be about the same as those from the benzene process.

DMT/TPA-Crude TPA. The reactor vent is the principal emitter of pollutants. The vent gas contains unreacted p-xylene, acetic acid, carbon dioxide, methyl acetate, and carbon monoxide. VOCs are emitted from vents at each stage of the process.

Emissions result from the storage of p-xylene, acetic acid and n-propyl acetate. There are no VOC handling emissions since crude TPA is transferred in solid form, and by-product waste methyl acetate is transported by pipeline to incinerators. Fugitive VOC emissions also occur from this process.

This report does not include costs for control of emissions from DMT production from crude TPA or purified TPA production from crude TPA. Adequate data are unavailable for costing control of DMT production emissions. Emissions from purified TPA production are insignificant.

Regulations

SIPs. The applicable air-pollution regulations are the various state requirements for the control of volatile organic compounds (VOCs), carbon monoxide, and particulate organic materials. Only a few states established VOC regulations in their original 1972 SIPs, but almost all states (especially those with non-attainment areas for ozone) set limits for VOC sources in SIPs revised after 1977. Most states pattern their SIPs after Appendix B RACT (40 CFR Part 51) or LA Rule 66.

NESHAPs. NESHAPs were proposed for Benzene Emissions from Maleic Anhydride Plants on April 18, 1980 (45 FR 26660), Benzene Emissions from Ethylbenzene/Styrene plants on December 18, 1980 (45 FR 83448), Benzene Fugitive Emissions on January 5, 1981 (46 FR 1165) and Benzene Emissions from Benzene Storage Tanks on January 19, 1980 (45 FR 83952).

The two NESHAPs for benzene process emissions are more stringent than typical SIP VOC regulations. For a new production unit in a sufficiently large maleic anhydride plant, the maleic anhydride NESHAP would permit no detectable benzene emissions. (Required controls for existing plants are somewhat less stringent.) The ethylbenzene/styrene NESHAP would set limits for benzene emission from each process vent stream at new and existing ethylbenzene/styrene plants.

Benzene fugitive emissions would be limited from sources containing liquids with ten percent or more benzene by weight. The proposed standard would allow no detectable emissions due to leaks from safety/relief valves and product accumulator vessels. The standard would require a leak detection and repair program for pipeline valves and existing pumps and compressors and would require certain specific equipment for new pumps, compressors, sampling connections, and open-ended valves.

The NESHAP for benzene storage vessels affects tanks with capacity greater than four cubic meters. Each new and existing storage tank would be required to have a fixed roof plus an internal floating roof that rests on the liquid surface inside the vessel. Each storage vessel would also need a liquid-mounted primary seal and a continuous secondary seal. Periodic inspections would be required.

NSPS. EPA proposed a NSPS for VOC Fugitive Emission Sources in the Synthetic Organic Chemical Industry on January 5, 1981 (46 FR 1136). It would require a leak detection and repair program for valves and would specify certain equipment to reduce VOC emissions from pumps, compressors, sampling connections and open-ended lines. Leaks from safety/relief valves would be prohibited during normal operations. The standard would apply only to equipment containing 10 percent or more VOC.

Other "generic" regulations expected to be proposed are a NSPS for Air Oxidation Processes in the Synthetic Organic Chemical Industry and a NSPS for Volatile Organic Liquid Storage.

Control Technology

Formaldehyde - Silver Catalyst. VOC and CO emissions from the product absorber vent can be reduced by 99 percent if the vent stream is oxidized by thermal oxidation in a waste heat boiler. This option was chosen for cost estimation purposes because the high heat value of the gas makes it more cost-effective than flaring or catalytic oxidation.

Product fractionator vent VOC emissions can be controlled by condensing and recycling the gas stream to the secondary absorber, thus obtaining essentially 100 percent reduction in emissions. Storage and handling VOC emissions can be reduced by an estimated 96 percent by installing vent scrubbers to scrub vapors emitted and collected in formaldehyde storage and handling areas. Controls for fugitive emissions from sources such as pumps, valves, and other equipment can be reduced by an estimated 81 percent through repair and maintenance programs.

The above-mentioned control technology, which is assumed for costing, yields an estimated reduction of 94 percent of the total VOC emissions for the silver catalyst process. Approximately one third of existing plants were in compliance with SIPs in 1979. In estimating control costs, it was assumed that the remainder would be in compliance by 1983.

Formaldehyde - Metal Oxide. The absorber vent emission of VOCs and CO can be reduced by an estimated 99 percent by thermally oxidizing the gas stream. The vent gas is largely inert, making preheating of the incoming stream with recuperative heat exchangers the most cost-effective thermal oxidation system.

Storage and handling VOC emissions can be reduced by 96 percent by employing a vent scrubber system to scrub formaldehyde storage and handling vapors. The VOC content of fugitive emissions can be reduced by 74 percent by repairing and maintaining equipment and by efficient detection and repair of leaks.

A reduction of 91.2 percent can be obtained in the total VOC content of emissions if the above mentioned control technologies are used. Approximately eight percent of the plants were in compliance with SIPs as of 1979. In estimating control costs, it was assumed that the remainder would comply by 1983.

Acrylonitrile. Absorber vent VOC, CO, and acrylonitrile emissions can be reduced by 99 percent by thermal oxidation of the vent gases. Thermal oxidation is most cost-effective when used in conjunction with a recuperative heat recovery system to preheat incoming gas streams. VOC emissions from the column vents are reduced 99 percent by incineration in a flare. The reduction in total VOC emissions from the acrylonitrile production process is 86.4 percent when the above mentioned control technologies are employed.

For the purpose of estimating control costs, it was assumed that 50 percent of acrylonitrile plants complied with SIPs by 1979 and the remainder would comply by 1983.

Ethylene Oxide - Air-Oxidation. The technology currently employed to reduce main process vent VOC emissions is catalytic oxidation. Catalytic oxidation has a VOC removal efficiency of 95 percent and is most cost-effective when used in conjunction with a waste heat boiler.

VOC emissions from the stripper purge vent are currently compressed and recycled to the process (purge reactor). This system can produce a control efficiency of 97.3 percent.

Combining these two technologies (catalytic oxidation and recycle) provides a reduction in total VOC emissions from the air-oxidation process of 90.9 percent. Conversations with EPA personnel suggest that all air oxidation plants have been in compliance with SIPs since at least 1979.

Ethylbenzene/Styrene (Styrene from Benzene-Ethylene). VOC emissions from the alkylation reaction section can be controlled by incinerating the emissions and using the heat for a process boiler. This technique lowers the emissions by more than 99.9 percent. VOC emissions from the various column vents and from the emergency vent on the separator can be reduced by 99 percent by venting through a flare. These controls are sufficient to meet SIPs and NESHAPs. It was assumed that plants subject to SIPs would reach full compliance by 1983 and those subject to NESHAPs, by 1984.

An adequate maintenance program lowers fugitive emissions by up to 74 percent. Storage and handling emissions are controlled in various ways. Floating-roof tanks reduce benzene storage emissions by 85 percent. Floating roof tanks are also used for ethylbenzene and toluene storage, with the same control effectiveness. Because such storage emission control techniques yield a net credit, their costs are not reported in this chapter. Styrene, crude styrene, and tar storage tanks may be vented through the column vent flare system. This procedure reduces emissions by 99 percent. Crude ethylbenzene storage tanks may be fitted with refrigerated vents that reduce benzene emissions by 80 percent. The VOC emissions from other storage facilities at these plants are insignificant and not controlled.

If all of these controls are used at plants employing this process, 92.6 percent of the benzene emissions and 92.5 percent of the VOC emissions are controlled.

For existing styrene plants to comply with the Ethylbenzene/Styrene NESHAP, the plants would need to retrofit a piping system to transport the vent gas to the existing process boilers. Additional burners and controls must also be added. Fifty percent of the plants are assumed to comply within 90 days and the remainder, two years after promulgation.

Maleic Anhydride. (Benzene Oxidation Process) VOC emissions from the main product recovery vent and from the refining vacuum vent can be controlled by either carbon adsorption or incineration. Both VOC and benzene emissions can be reduced by 99 percent. The cost estimates for both SIP and NESHAPs compliance in this chapter are based on use of incineration rather than carbon adsorption. Plants subject to SIPs are assumed to comply by 1983 and those subject to NESHAPs, by 1984.

Fugitive emission control with a properly designed maintenance program reduces VOC emissions by up to 73 percent and benzene emissions by almost 82 percent.

Storage and handling emissions may be controlled in various ways. Floating roof tanks reduce emissions from benzene storage by 85 percent. The emissions from maleic anhydride storage are controlled by an aqueous scrubber or a xylene scrubber. Although this is done more for housekeeping reasons (preventing buildup of solid maleic anhydride), these methods lower emissions by 99 percent. The emissions from o-xylene storage are insignificant and need not be controlled.

If all of these controls are used at plants employing the benzene oxidation process, 98.5 percent of the benzene and 98.3 percent of the VOC emissions are controlled. Based on discussions with EPA personnel, it was assumed that one-half of the plants would comply with the maleic anhydride NESHAP within a year and the remainder within two years after promulgation. Compliance with the benzene storage tank NESHAP by all existing sources was assumed to occur within two years after promulgation.

The control technologies for VOC emissions from the process which produces maleic anhydride by n-butane oxidation should be the same as those for the benzene oxidation process. The VOC emission reductions should also be similar. There are no benzene emissions to be controlled, however.

Because the butane process is not yet sufficiently documented, control costs for butane maleic anhydride were not estimated. Since it is assumed that all new plants will use butane feedstock, no new plant costs are presented.

DMT/TPA (Crude TPA Process). VOC emissions from the terephthalic acid process vents can be reduced 97 percent by carbon adsorption. Since there is a net credit resulting from this technique, the costs are not reported in this chapter.

Fugitive emissions can be reduced by up to 71 percent by a maintenance program. It is assumed that storage and handling emissions are controlled with an internal floating roof and secondary seal for NESHAP compliance. For purposes of this report plants comply with NESHAP storage requirements by 1984.

If all of these controls are used at plants employing this process, 95.7 percent of total VOC emissions are controlled.

Cost Methodology

Table 5.1.2 reports the air pollution control cost estimates for this industry. The costs were based on model plant cost functions for the sectors described in this chapter. As discussed above, costs for controlling process emissions from ethylene oxide - oxygen oxidation plants and new maleic anhydride plants were not included.

Product recovery credit functions were estimated separately for each sector where appropriate. As shown in Table 5.1.2, plants subject to NSPS have net O&M savings for 1981 through 1990. There is a net annual cost for these plants, however, because the capital costs are large relative to the O&M savings.

Fugitive emission control costs were estimated by using a cost function approach. However, a measure of plant complexity was used as the basis for the function instead of plant capacity. Each petrochemical was assigned to a complexity class based on the physical makeup of typical plants.

The main sources of cost data were Organic Chemical Manufacturing, Volumes 6-10 (EPA 450/3-80-028a through e) and the background information documents prepared by EPA for the proposed NESHAP and NSPS.

Table A5.1.2. Petrochemicals industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	11.41	31.82	37.94	58.34	108.30
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	2.00	9.33
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	0.0	0.0	0.0	10.19	10.19
TOTAL	11.41	31.82	37.94	70.54	127.83
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	11.35	8.96	28.53	70.86	150.56
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.49	6.45
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	0.0	0.0	0.0	2.84	12.80
TOTAL	11.35	8.96	28.53	74.19	169.80
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.54	0.07	1.59	1.76	0.42
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	-0.32	-4.26
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	0.0	0.0	0.0	3.29	16.39
TOTAL	0.54	0.07	1.59	4.73	12.55
TOTAL ANNUAL COSTS	11.90	9.03	30.13	78.91	182.35

Chapter A5.2 Vinyl Chloride

This chapter discusses the vinyl chloride industry and other chemical industries whose processes emit vinyl chloride to the atmosphere. The end products of such processes include vinyl chloride monomer (VCM), ethylene dichloride (ED) manufactured by oxychlorination in a balanced EDC-VCM plant, and polyvinyl chloride (PVC) and copolymers of PVC. Revision of this chapter included adjusting the costs to 1981 dollars and updating the discussion of applicable regulations.

Regulations

A NESHAPS for vinyl chloride, a hazardous pollutant (40 CFR 61.60), was promulgated on October 21, 1976. The vinyl chloride limitations, which are summarized in Table A5.2.1, cover processes in vinyl chloride plants, ethylene dichloride plants, and polyvinyl chloride plants.

These plants would also be subject to two NSPS currently under development to regulate volatile organic compounds (VOC), including vinyl chloride. One NSPS will govern VOC emissions from volatile organic liquid storage containers. The other will regulate fugitive VOC emissions in the synthetic organic chemical manufacture industry, which includes these plants.

The vinyl chloride standard is being reviewed to evaluate its adequacy and appropriateness in light of new information on health effects, technology, and compliance and enforcement experience with the standard.

Industry Characteristics

Vinyl chloride is produced in the United States by two methods: the addition of hydrogen chloride to acetylene and the dehydrochlorination of ethylene dichloride. Only two plants in the United States use the first method.

Ethylene dichloride is also produced by two methods: the catalytic chlorination of ethylene with chlorine and the oxychlorination of ethylene with hydrogen chloride and oxygen.

The major use for ethylene dichloride in the United States is in the production of vinyl chloride. It is usually convenient and economical to manufacture both products in the same plant in a balanced operation in which part of the ethylene dichloride requirement for the plant is produced by the chlorination of ethylene with chlorine. After purification, the ethylene dichloride is converted to vinyl chloride and hydrogen chloride in a cracking furnace operating at about 510 C (950 F) dehydrochlorination of ethylene dichloride). Hydrogen chloride is recovered and recycled to an oxychlorination process for the conversion of additional ethylene to additional ethylene dichloride (oxychlorination of ethylene). In this

Table A5.2.1. Vinyl chloride emissions limitations

Emission source/process	Limitation
Balanced ethylene dichloride - vinyl chloride plants	
EDC formation and purification	10 ppm
VCM formation and purification	10 ppm
Oxychlorination process	0.2 g/kg (0.4 lb/ton) EDC
Relief valve discharges	prohibited*
Manual venting of gases	prohibited*
Polyvinyl chloride plants	
Equipment through stripper	10 ppm
Equipment following stripper	2000 ppm (dispersion resins) 400 ppm (all other resins)
Reactor openings	0.02 g/kg (0.04 lb/ton) PVC
Relief valve discharges	prohibited*
Manual venting of gases	prohibited*

*Except under emergency conditions

manner, essentially all of the chlorine that is used eventually winds up in vinyl chloride.

Polyvinyl chloride (and copolymer) is produced by the catalyzed polymerization of vinyl chloride (and comonomers).

Four types of processes are used in the United States to effect this polymerization. These processes and the percentage of total U.S. capacity each represented in 1973 are as follows: suspension polymerization (78 percent), dispersion or emulsion polymerization (13 percent), bulk polymerization (6 percent), and solution polymerization (3 percent).

The production of ethylene dichloride, vinyl chloride, and polyvinyl chloride was 1.15, 0.91, and 0.82 million metric tons (1.27, 1.0 and 0.91 million short tons), respectively, in 1965. By 1974 these had grown to 4.2, 2.60, and 2.15 million metric tons (4.6, 2.9, and 2.4 million short tons). Growth of the production of these chemicals is projected to continue at an average annual rate of approximately 4 percent. This report and its estimations of air-pollution control costs are based on the current regulations for controlling vinyl chloride emissions. It is not believed that meeting these regulations will have a particularly adverse impact on the production of polyvinyl chloride and its precursors. However, if certain contemplated control regulations are promulgated, such as zero discharge of vinyl chloride emissions from all establishments, the costs may be higher.

Pollutants and Sources

The primary air pollutant of concern in the manufacture of ethylene dichloride (by oxychlorination), vinyl chloride, and polyvinyl chloride is vinyl chloride monomer (VCM). When VCM is incinerated as a means of control, hydrogen chloride becomes a by-product air pollutant.

The contributions of vinyl chloride emissions from the uncontrolled sources in an EDC-VCM plant are shown in Table A5.2.2.

The contributions of various emission sources to total emissions of vinyl chloride differ somewhat from process to process, but the breakdown shown in Table A5.2.3 for the dispersion process is generally typical for other processes.

Control Technology

The best available control technology for balanced EDC-VCM plants involves the collection and incineration of all emissions from the formation and purification of vinyl chloride and ethylene dichloride (by oxychlorination) and the control of fugitive emission sources. Fugitive emissions can be controlled by the use of:

- Multipoint and portable detectors

Table A5.2.2. Uncontrolled sources of vinyl chloride emissions in VCM production

Emission source	Uncontrolled emissions at average plant, percent
Vinyl chloride formation and purification	54
Fugitive emission sources	27
Ethylene dichloride purification	11
Oxychlorination reactor	8
Total	100

Table A5.2.3. Uncontrolled sources of vinyl chloride emissions in PVC production (dispersion process)

Emission source	Uncontrolled emissions at average plant, percent
Sources following stripper*	33
Stripper	8
Fugitive emissions sources	38
Monomer recovery system	12
Relief valve discharge	5
Reactor valve discharge	4
Total	100

*Slurry blend tanks, concentrators, dryers, bulk storage, etc.

- Control systems on sampling and transfer operations

- Collection header systems to connect equipment undergoing maintenance or inspection to either the monomer recovery system or to an add-on control device

- Rupture discs and pressure gauges prior to safety discharge valves on pressure vessels and

- Dual mechanical seals on pumps and compressors.

It is anticipated that fugitive emissions can be reduced by 90 percent by applying these above measures in the typical plant. Incineration should reduce emissions form the other sources by at least 95 percent.

The best available control technology for PVC plants varies somewhat with the type of process. For all processes, fugitive emissions can generally be controlled through containment, capture, and ducting of emissions to a control system, and early leak detection and repair. Losses on opening equipment can be reduced by using water to displace VCM to a control system before opening the equipment. Reactor relief valve discharges can generally be eliminated by chemically short-stopping the polymerization reaction or manually venting gases to a recovery system. Strippers are used to remove vinyl chloride from the polymer, and carbon adsorption systems can be used to recover the monomer from the stripper.

Improved stripper effectiveness solves most of the emissions problems in operations that follow the stripper, including emissions of VCM in PVC fabrication operations, although incineration with scrubbing to remove HCl is an alternative control strategy. Emission control effected by the stripper, however, is not uniformly applicable to all processes. Current technology is available to strip the majority of resins except dispersion resins to 400 ppm or lower. Dispersion resins, however, are sensitive to the high temperatures used in stripping other resins, but they can be stripped effectively to 2,000 ppm. Most of the remaining VCM is removed from dispersion resins in the drying process.

Suspension resins and dispersion resins are polymerized in water and are ultimately blended in water slurry. This water contains some vinyl chloride, which can be removed by steam distillation. No water is involved in the bulk polymerization process, so this emission source does not exist for the bulk process. However, this process accounts for only about 6 percent of U.S. PVC production. No consideration is given here to the solution process, which is practiced by only one company and accounts for only about 3 percent of production.

Costing Methodology

Capital costs and annual operating and maintenance costs were estimated for model plants using factors derived from the EPA Support Document. It is assumed that very few plants were in compliance before the regulations were promulgated in 1976. Full compliance for most existing plants should have been completed by 1978, although it may be 1980 before all dispersion PVC plants can be brought into compliance.

The costs developed on this basis are listed in Table A5.2.4. The industry sectors and regulations costed include the following:

Sector	Regulation
EDC-VCM Balanced-small plants	NESHAPS
EDC-VCM Balanced-large plants	NESHAPS
PVC-Dispersion	NESHAPS
PVC-Suspension	NESHAPS
PVC-Bulk	NESHAPS

Table A5.2.4. Vinyl chloride

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .138E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	14.02	16.78	40.43	86.03	169.07
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	0.0	94.49	182.94	182.94	0.0
TOTAL	14.02	111.27	223.38	268.98	169.07
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	7.52	2.78	17.11	51.51	171.71
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	36.48	15.26	106.73	216.16	364.76
TOTAL	44.00	18.03	123.84	267.66	536.46
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	11.72	5.20	27.05	79.79	260.55
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	40.62	28.13	118.76	240.62	406.18
TOTAL	52.34	33.33	145.81	320.41	666.74
TOTAL ANNUAL COSTS	96.34	51.37	269.65	588.07	1203.20

Chapter A5.3 Nitric Acid Industry

Revision of this chapter was limited to adjusting pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

Both NSPS and SIPs limit nitrogen oxides (nitrogen dioxide) emissions from nitric acid plants. Nitric acid plants were among the first facilities for which NSPS were promulgated on December 23, 1971 (40 CFR 60.70). The NSPS limits nitrogen dioxide emissions and plume opacity from process equipment.

The SIPs of many states contain nitrogen oxides limits that are patterned after either the NSPS or suggested RACT standards for nitric acid plants (40 CFR 51, App. B). Several states specify that the NSPS and RACT standards based on 100 percent strength nitric acid also apply to plants that manufacture weak nitric acid (30-70 percent strength). Several states have opacity standards stricter than NSPS.

Industry Characteristics

Nitric acid is produced in 96 privately-owned and 12 government-owned production plants ranging in size from 14 to 390,000 metric tons per year.

Nitric acid is used in the manufacture of ammonium nitrate and in numerous other chemical processes. Ammonium nitrate, which is used both as a fertilizer and in explosives, accounts for about 80 percent of the nitric acid consumption. Nitric acid is produced by oxidation of ammonia, followed by absorption of the reaction products in dilute acid solution. Most nitric acid plants in the United States are designed to manufacture acid with a concentration of 55 to 65 percent, which may subsequently be dehydrated to produce 99 percent acid.

The chemical, petroleum and fertilizer industries produce 47, 12, and 34 percent of the acid, respectively, to account for 93 percent of the total; lesser quantities are produced by the primary iron and steel and aluminum industries. Total production in the private sector in 1978 was about 7.30 million metric tons, which shows only a 1.0 percent annual growth rate from 1970's production rate of 6.74 million metric tons. In January, 1979, total capacity of the private sector was 10.6 million metric tons while the government-owned plants represented an additional 1.1 million tons per year.

Pollutants and Sources

Nitrogen oxides, the primary pollutants of concern in the production of nitric acid, are emitted in the tail-gas from absorption towers. Numerous variations on the basic nitric acid production process affect both the emissions and difficulty of control. Two of the more important variables are the amount of excess oxygen present in the absorption tower and the pressure under which the absorption tower operates. Many plants practice partial pollution abatement (decolorization) in accordance with local regulatory agencies. Under this practice, the highly visible reddish-brown nitrogen dioxide is converted to colorless nitric oxide. Although visible emissions are reduced, the practice does nothing to prevent emission of nitrogen oxides to the atmosphere.

Control Technology

Catalytic reduction with natural gas is a feasible and proven control technology used in nitric acid plants both here and abroad. The absorber tail-gas is mixed with 38 percent excess natural gas and passed over a platinum or palladium catalyst. Catalytic reduction with ammonia or hydrogen has the advantage of being selective in the sense that only the nitrogen oxides are reduced. However, in addition to higher costs, reduction with ammonia requires close temperature control to prevent the reformation of nitrogen oxides at higher temperatures or the formation of explosive ammonium nitrate at lower temperatures. Catalytic reduction is appropriate both in new plants (construction started since 1972) and older facilities to meet both SIP and NSPS requirements; reductions in nitrogen oxide emissions by about 93 percent are achieved.

Costing Methodology

Cost functions derived from published papers and an EPA report were applied to arrays of data showing plant capacity range, average capacity, and number of plants within a capacity range. These were applied to both government- and privately-owned plants for new and old plants to meet NSPS and SIP standards; all plants were assumed to be required to meet such standards. It has been assumed that the government-owned plants achieved compliance by 1975 for both SIPs and NSPS; privately owned plants were assumed to have achieved NSPS since 1975 but will not achieve SIP compliance until 1980, having started in 1973.

The costs developed for this industry are shown in Table A5.3.1.

Table A5.3.1. Nitric acid industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	39.07	17.21	18.54	50.72
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.41	9.25	1.21	2.46	12.37
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.41	48.32	18.42	21.00	63.09
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	8.66	13.69	25.99	51.98	84.49
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.61	3.38	4.65	9.86	18.26
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	10.28	17.07	30.64	61.84	102.75
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	10.81	16.82	32.42	64.83	108.06
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.19	8.78	12.08	25.62	49.43
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	14.99	25.60	44.49	90.46	157.49
TOTAL ANNUAL COSTS	25.27	42.67	75.13	152.30	260.24

Chapter A5.4 Sulfuric Acid Industry

Revision of this chapter was limited to adjusting pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

Sulfuric acid plants were in the first group of industries for which NSPS were promulgated on December 23, 1971 (40 CFR 60.80). The NSPS sets sulfur dioxide, sulfuric acid mist, and opacity standards for process equipment of sulfuric acid plants.

Since sulfuric acid mist is not a criteria pollutant, the setting of a NSPS for mist forces the states to establish standards for sulfuric acid mist as a designated pollutant for existing sulfuric acid plants (40 CFR 62). On October 18, 1977 (42 FR 55796), EPA issued guidelines to states for setting sulfuric acid mist limits for existing plants.

Many states' SIPs have regulations identical to the NSPS; some apply to new plants and some, to new and existing plants. At least one state has opacity standards more stringent than the NSPS. Other states patterned their regulations of existing plants after the RACT sulfur dioxide limits for sulfuric acid plants suggested in Appendix B (40 CFR 51, App. B) and the guideline sulfuric acid mist limits. A number of states, however, have not yet required existing plants to meet standards as strict as any of these limitations.

Industry Characteristics

Sulfuric acid is manufactured by chemical and fertilizer companies and by companies primarily engaged in smelting nonferrous metals; both sources compete for the same buyers. Nevertheless, the sulfuric acid manufactured by the smelter industry is primarily a by-product resulting from efforts to reduce sulfur dioxide emissions to the atmosphere, and secondarily, as an attempt to generate additional revenue. For the purposes of this report, smelter produced acid is considered to be part of the smelter industry rather than the sulfuric acid industry.

The major products of the sulfuric acid industry are concentrated sulfuric acid (93 to 99 percent) and oleum. A few sulfuric acid plants associated with the fertilizer industry produce less-concentrated grades of acid. Essentially, all sulfuric acid in the United States is produced by the contact process, less than 0.1 percent being produced by the older chamber process.

About 65 percent of the sulfuric acid produced in the United States is used in the manufacture of phosphate fertilizers; the rest is used in myriad industrial applications ranging from steel pickling to detergent manufacturing.

In sulfur-burning plants, sulfuric acid is produced by burning elemental sulfur with dry air in a furnace to produce sulfur dioxide. The latter is catalytically converted to sulfur trioxide. The hot converter effluent is cooled and introduced to an absorption tower where the sulfur trioxide is absorbed in a sulfuric acid solution to form more sulfuric acid by its reaction with water.

Some plants (including spent-acid plants and smelter-gas plants) operate on the same principle as sulfur-burning plants, except that the sulfur dioxide is obtained from the combustion of hydrogen sulfide or from smelter off-gas. In these plants, the sulfur-bearing gas is dried with sulfuric acid and cleaned (subjected to particulate and mist removal process) before introduction to the acid plant.

As of January 1, 1979, 59 companies operated sulfur-burning or wet-process contact acid plants in 121 locations and 13 companies operated smelter-acid plants in 24 locations; only 1 company operated a chamber acid plant in one location. Production plants range in size from 4,500 to 1,823,400 metric tons per year.

In 1978 production of sulfuric acid was about 35.9 million metric tons of which about 3.6 million metric tons was smelter acid. Although 1977 and 1978 each showed increases in production of about 10 percent annually, longer term forecasts are more in the range of a growth rate of about 3.5 percent per year. Total capacity of contact acid plants excluding smelter-gas-based plants was 38.6 million metric tons per year on January 1, 1979; capacity including smelter-gas plants was 44.6 million metric tons per year.

Pollutants and Sources

Emissions from sulfuric acid plants consist of sulfur dioxide gases and sulfuric acid mist. These pollutants evolve from incomplete conversion of sulfur dioxide to sulfur trioxide in the converter, and from the formation of a stable mist consisting of minute particles of sulfuric acid that resist absorption in the acid absorber.

Control Technology

Control of sulfur dioxide emissions may be achieved by the use of several technologies including molecular sieves, the Wellman-Lord process, ammonia scrubbing, and dual absorption. Because dual absorption acceptably meets EPA standards and is universally applicable, its costs were used in computing SO_2 control costs.

Control of acid mist to meet NSPS can be reliably met only through the use of vertical tube demisters. SIP guidelines can be met in sulfur burning plants producing acid and weak oleum by the less costly vertical panel or horizontal dual pad demisters. However, in plants using chemical-bound sulfur as feedstock or producing strong oleum (<20 percent SO_3) only the vertical tube demister is reliable.

Costing Methodology

Cost functions were derived from data in numerous sources over the period 1974 to 1977 including EPA Guideline Documents and were applied to arrays of data showing plant capacity range, average capacity, and number of plants within a given capacity range. Data on industry characteristics reflect information available in the published literature up through 1979.

NSPS costs were applicable to plants put on stream after January 1, 1975. SIP costs for SO_x control on existing plants were estimated to start in 1973 and be completed in 1980. SIPs on acid mist were not effective until 1979, and it was estimated that most installations were complete by late 1981.

The costs developed on the above basis are shown in Table A5.4.1. The costs do not include costs of controls for smelter-acid plants.

Table A5.4.1. Sulfuric acid industry

[illegible]
[illegible]
[illegible] .0

	[illegible]	[illegible]	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	[illegible]	[illegible]	106.05	163.87	571.93
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	[illegible]	[illegible]	22.04	47.99	139.90
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	[illegible]	[illegible]	128.09	211.86	711.83
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	[illegible]	[illegible]	270.82	569.78	967.57
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	[illegible]	[illegible]	28.62	68.49	166.14
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	[illegible]	[illegible]	307.44	638.27	1133.72
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	[illegible]	[illegible]	355.25	701.47	1039.81
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	[illegible]	[illegible]	175.12	409.16	623.51
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	[illegible]	[illegible]	530.36	1110.63	1663.32
TOTAL ANNUAL COSTS	[illegible]	[illegible]	837.80	1748.90	2797.04

Chapter A5.5 Phosphate Fertilizer Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and expanding the discussion of applicable regulations.

Regulations

Five NSPS covering fluoride emissions from the phosphate fertilizer industry were promulgated on August 8, 1975 (40 CFR 60.200, 210, 220, 230, 240). Specific standards were established for different industry sub-classes or processes as follows:

Total Fluoride Emission Limit
(grams per metric ton of phosphorus feed)

Subclass or Process	Limit
Wet process phosphoric acid plants	10.00
Superphosphoric acid plants	5.00
Diamonium phosphate plants	30.00
Triple superphosphate plants	100.00
Granular triple superphosphate storage facilities	0.25*

*grams/hour/metric ton

Since fluoride is a designated pollutant, states are required to revise their SIPs to include fluoride standards for existing phosphate fertilizer plants. The EPA guidelines for fluoride standards, which were issued March 1, 1977, recommended that states use the NSPS standards.

Process weight standards and other general particulate emission limitations in SIPs govern the particulate emissions from phosphate fertilizer plants. A NSPS for phosphate rock plants (40 CFR 60.400), which was promulgated April 16, 1982, set particulate limits for the processes that prepare phosphate rock for conversion to phosphate fertilizer. The costs of complying with this recent NSPS are not included in this chapter.

Industry Characteristics

The major products of the phosphate fertilizer industry are ammonium phosphates, triple superphosphate (TSP), normal superphosphate (NSP), and granular mixed fertilizers (NPK). Phosphoric acid and superphosphoric acid are intermediate products.

All phosphate fertilizers are processed from ground phosphate rock treated with sulfuric acid to produce either normal superphosphate or wet-process phosphoric acid. A phosphoric acid intermediate may then be reacted with ammonia to produce diammonium phosphate and other ammonium phosphates, or reacted with ground phosphate rock to manufacture triple superphosphate. Superphosphoric acid, produced by dehydration of wet-process phosphoric acid, is used in preparing some mixed fertilizers. Granular mixed fertilizers are made from either normal superphosphate or triple superphosphate, with ammonia and potash. Bulk-blended mixed fertilizers and liquid mixed fertilizers are manufactured by physically mixing particles of other fertilizer components.

The phosphate fertilizer industry is characterized by a number of large, modern, efficient plants located near the source of raw materials. In general, these plants manufacture more concentrated forms of fertilizer, diammonium phosphate (DAP and triple superphosphate (TSP). These industries are found particularly in Florida.

Smaller plants, located near the retail markets, manufacture the less concentrated forms: granulated mixed fertilizer (NPK) and normal superphosphate (NSP). The smaller NSP, NPK, and bulk-blend plants are located in the farming states.

Due to the seasonal demand for fertilizer, many plants manufacturing NSP and NPK operate only a portion of the year. In contrast, those plants manufacturing DAP and TSP generally operate year-round.

Pollutants and Sources

Emissions from phosphate fertilizer processing plants are mainly fluorides (in the form of hydrogen fluoride and silicon tetrafluoride) and particulates. Fluorides are generated in the processes of acidulation of phosphate rock which contains calcium fluoride.

In the phosphate fertilizer industry, particulate emissions of significance originate from: phosphate rock grinding; TSP manufacture; DAP production; NSP manufacture; and NPK bulk-blending and granulation plants.

In phosphate rock processing, particulate emissions are issued from the drying, grinding, and transfer processes. The emission factors for these processes are 7.5, 10, and 1 kg per metric ton (15, 20, and 2 pounds per short ton) of rock respectively.

In granular TSP production, particulate emissions may originate from a number of points in the process. Most of the particulates are given off in the drying and product-classification processes. The off-gas from the reactor (in which phosphate rock is acidulated with phosphoric acid) and the blunger (in which the reactor effluent is mixed with recycled product fines to produce a paste) may account for a considerable percentage of the total particulates emitted.

Particulate emissions from DAP manufacture originate mainly from the granulator and the dryer. It has been estimated that the total emissions amount to approximately 20 kg per metric ton (40 pounds per short ton) of product from both sources.

Emissions from the manufacture of run-of-pile NSP originate from both the acidulation and "denning" processes. Although the emission factors for particulates are not known, they are estimated to be in the order of 5 kg per metric ton (10 pounds per short ton).

The NPK or granulation plants manufacture a variety of products. Many emission factors probably will apply for this class of fertilizer plant. In fixing the emission factors, these plants are assumed to employ an ammoniation-granulation process similar to that used in the DAP process, or to emit approximately 20 kg of particulates per metric ton of product (40 pounds per short ton).

The emission factors for particulates are high in the TSP, DAP, and NPK plants. The bulk of these emissions in all three processes originates from the granulation process. There is a strong economic incentive to reduce these emissions since they contain valuable products and in many cases are associated with ammonia vapors (from the ammoniation process), whose recovery is an economic necessity.

Control Technology

Most of the phosphate rock of higher available phosphorus pentoxide content is ground and beneficiated to enhance its reactivity and to eliminate some of the impurities. The particulate emissions from the grinding and screening operations may be controlled effectively by baghouses in which the dust is deposited on mechanically cleaned fabric filters. The dust-laden gas from the rock-drying (and perhaps defluorination) operations may first pass through a cyclone and then through a wet scrubber (such as venturi). The efficiency of this combination should be better than 99 percent.

Particulate and fluoride emissions from phosphate fertilizer plants traditionally have been removed from gaseous waste streams by wet scrubbing. While efforts have been directed at removing fluorides, up to 99 percent of the particulates are simultaneously removed. Wet scrubbers of varying efficiencies have been used for this double purpose. The fluoride and particulate-laden scrubber water is usually disposed of in a gypsum pond.

For control of particulate emissions from granular TSP plants, it is assumed that various wet scrubbers will be provided for a number of gaseous waste streams. The effluent from the reactor-granulator is assumed to be scrubbed in two stages, first by a cyclone and second by a cross-flow packed scrubber. The gases from the drier and cooler are assumed to be scrubbed in venturi-type packed scrubbers. Waste gases from storage of the granular product are usually scrubbed in a cyclone scrubber, although some plants use packed scrubbers. The scrubbing liquid used in all scrubbers is assumed to be recycled pond water except for the first-stage scrubbing of gases from the reactor-granulator, where weak phosphoric acid is used and recycled to the reactor.

In DAP plants, control of particulates is assumed to be achieved for gaseous streams originating from the reactor-granulator, the drier, and the cooler, together with combined gaseous streams ventilating such solids-processing equipment as elevators, screens, and loading and unloading. Two-stage scrubbing is assumed to be employed for each of the streams listed. The first stage is assumed to consist of a cyclone scrubber; the scrubbing medium is diluted phosphoric acid (30 percent) for purposes of recovering ammonia and the product. Most of the particulate matter is assumed to be removed in the first stage, and the balance in the second stage consisting of a cross-flow packed scrubber in which recycled pond water is used as the scrubbing medium.

It is assumed that only run-of-pile normal superphosphate is produced in NSP plants. A cyclone scrubber often is employed in removing particulates in gaseous streams originating from the reactor-pugmill, den, and curing operations.

An ammoniation-granulation process is assumed for NPK plants. Cyclones are normally installed ahead of primary scrubbers. The primary scrubber (typically employing dilute phosphoric acid as a scrubbing medium) is considered an integral part of the process in which valuable reactants (ammonia) and the product are recovered.

Cross-flow scrubbers have been used in estimating costs of controlling emissions of both particulates and fluorides. Most of the control technologies described above have been applied for more than a decade. Wet scrubbers of varying efficiencies have been integral parts of many phosphate fertilizer processes. The collection of waste gaseous streams and the removal of fluoride compounds from these streams has long been practiced to protect the health and safety of process operating personnel. Collection of particulate materials from those waste gaseous streams is dictated by economic necessity because valuable products are involved.

Costing Methodology

As shown in Table A5.5.1, there are no costs which are attributable to air pollution regulations. This is the result of widespread use of control devices as a part of industry processes. EPA has issued guidelines (Federal Register, March 1, 1977) by which the States are to control fluoride emissions. Costs may accrue in the future, depending on the regulations in revised State Implementation Plans.

Table A5.5.1. Phosphate fertilizer industry

AIR POLLUTION CONTROL COSTS
(IN BILLIONS OF DOLLARS)
CAPITAL IN PLACE (NIPS): .000E+00

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	40.76
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	40.76
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	10.36
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	10.36
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	22.79
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	22.79
TOTAL ANNUAL COSTS	0.0	0.0	0.0	0.0	33.15

Chapter A5.6 Nonfertilizer Phosphorus Chemicals

This chapter includes the production of elemental phosphorus, defluorinated phosphate rock, and feed-grade calcium phosphate. Revision of this chapter was limited to adjusting pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

SIPs govern the particulate and fluoride emissions from the defluorination processes in this industry. Particulate control is required for these processes to meet the general process weight standards and other types of limitations found in most SIPs. Several states have also established control regulations for fluorides. The fluoride emission cost estimates for the industry were based on the Florida standard.

There is no NSPS for this industry. The NSPS for phosphate rock plants specifically excludes mining, beneficiation, thermal defluorination, elemental phosphorus production, and nodulizing.

Industry Characteristics

In 1979, 21 plants were engaged in producing elemental phosphorus, defluorinated phosphate rock (DFP), and feed-grade calcium phosphates (Dical). The combined capacity of these plants was approximately 1.9 million metric tons per year (2.1 million short tons per year) (P_2O_5 equivalent) in 1979. Nine plants producing elemental phosphorus account for nearly 60 percent of the total capacity (P_2O_5 basis) involved in producing these nonfertilizer phosphorus products. A summary of model plant size distributions and capacities for the three products is provided in Table A5.6.1.

The production of industrial phosphorus and phosphate-containing animal feeds begins with thermal and/or chemical processing of phosphate rock. Phosphates that are suitable as additives to feeds may result from the direct defluorination of phosphate rock, defluorination of phosphoric acid from wet-process acid, or by use of furnace acid (made from elemental phosphorus). The production of feed-grade phosphates from furnace acid is not included here because the defluorination occurs in the phosphate reduction to elemental phosphorus, which is included. Furthermore, the production of furnace acid is declining because of the high energy requirements of the thermal reduction process. Decreased production by this process will be compensated for by increased production from wet process acids, so the overall production of feed-grade phosphates will increase at an annual rate of approximately 2 percent. Current production is estimated to be at about 70 percent of capacity.

Table A5.6.1. Model plant size distribution for the nonfertilizer phosphorus chemicals industry

Product	Number of plants	Plant capacity, 1000 metric tons/year		
		Product, average	P_2O_5 Equivalent	
			Average	Total
Elemental phosphorus (phosphate reduction)	3	14	31	93
	3	39	89	267
	3	101	231	693
				1,053
Defluorinated phosphate rock	3	61	28	84
	1	281	128	128
				212
Calcium phosphate	4	45	26	104
	3	120	69	207
	1	395	227	227
				538

Pollutants and Sources

Atmospheric emissions from the manufacture of defluorinated phosphates are primarily fluorides and particulates. Gaseous fluorides are released during the thermal and/or chemical reduction of phosphate rock with the major point of emissions in feed preparation. Emission factors may be as high as 33 kilograms of fluorine per metric ton (66 pounds per short ton) of phosphorus processed.

Control Technology

Fluorides can be controlled by wet scrubbers. These devices, which could include liquid ejector venturi scrubbers, liquid impingement control systems, and spray towers, also serve to control particulate emissions to levels of 95 percent or more.

Costing Methodology

An engineering and cost study by Resources Research Inc. and the TRW Systems Group for EPA in 1972 gave capital and operating costs (1971 dollars) for controlling fluoride emissions with scrubbing systems. These cost estimates were used as the basis for estimating costs for the various model plant sizes found in this study. Estimates of the costs in 1981 dollars of controlling fluoride emissions are given in Table A5.6.2.

Table A3.6.2. Nonfertilizer phosphorus chemicals

AIR POLLUTION CONTROL COSTS
(IN BILLIONS OF DOLLARS)
CAPITAL IN PLACE 1970: .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	7.53	0.0	0.0	2.57
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.20	1.80	0.60	1.22	3.48
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.20	9.33	0.60	1.22	6.05
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.99	3.00	2.97	5.94	9.79
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.32	0.89	0.87	1.98	4.44
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.30	3.89	3.84	7.92	14.22
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.27	0.84	0.83	1.65	2.73
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.18	0.39	0.39	0.89	2.03
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.42	1.23	1.21	2.54	4.76
TOTAL ANNUAL COSTS	1.72	5.12	5.05	10.46	18.99

Chapter A5.7 Mercury-Cell Chlor-Alkali Industry

Revision of this chapter was limited to updating the pollution control costs to 1981 dollars and rewriting the discussion of the applicable NESHAPS.

Regulations

The NESHAPS for mercury (40 CFR 61.50), promulgated on April 6, 1973, is the only federal regulation governing mercury-cell chlor-alkali plants. (A NSPS was considered in 1977, but development of that regulation was not pursued.) The NESHAPS covers mercury emissions from hydrogen and end-box ventilation gas streams and the cell room ventilation system.

Industry Characteristics

Twenty-seven plants manufacture chlorine in electrolytic mercury cells ranging in capacity from 99 to 626 metric tons per day. The size distribution is as follows:

Chlorine Capacity--1979

Number of plants	Metric Tons/Day		Percent of total capacity
	Range	Average	
8	<150	120	13.3
10	150 - 250	231	31.9
4	251 - 400	362	20.0
5	>400	503	34.8

These plants produce chlorine, caustic soda, and hydrogen. Nearly all of these plants are operated by the chemical industry (SIC 2812), except one plant that is operated by the primary aluminum industry (SIC 3334), representing 5.8 percent of industry capacity, and one that is operated by the pulp and paper mill industry (SIC 2611), representing an additional 3.2 percent of capacity.

Mercury-cell caustic soda has a higher purity than diaphragm-cell caustic soda, which is advantageous in selected applications. However, emerging technology will make the economical production of such high-purity caustic soda possible using diaphragm cell concepts. Thus, the future need for increased mercury-cell-derived caustic soda will likely be negligible; it is believed that some of the older mercury-cell plants will be shut down. However, improved mercury-cell technology has recently made possible the production of increased chlor-alkali products by redesign of existing cells, which has resulted in modest incremental increases in nameplate capacities of older plants. Although the overall chlorine-caustic soda industry is expected to grow at a rate of about 4 percent per year over the next decade, it is anticipated that all of this growth will use diaphragm-cell technology. In the meantime, it is anticipated that about 20 percent of the existing mercury-cell plants will close because of age for an effective "growth" rate of -2.2 percent per year.

Pollutants and Sources

Mercury is the pollutant of concern which arises from three principal sources:

- Mercury vapor and mist in by-product hydrogen
- End-box ventilation system
- Mercury-cell room general ventilation air.

Control Technology

Control technology for treatment of by-product hydrogen includes cooling, condensation, and demisting; depleted brine scrubbing; hypochlorite scrubbing; absorption on molecular sieves; and adsorption on treated activated carbon. End-box ventilation-system treatment technologies include the same methods as mentioned for by-product hydrogen except for adsorption on activated carbon. Strict adherence to good housekeeping and operating practice is the only suggested control technology for dealing with the mercury-cell room ventilation air. All of these techniques will be applied on a subprocess basis.

Costing Methodology

Costs were developed from data in a 1977 EPA draft document associated with the contemplated development of an NSPS. The control techniques and costs in this document are appropriate for compliance with the NESHAP. Generalized cost functions were developed and applied to a model of industry as shown in the following listing:

Number	Size, metric tons/day		Percent of total capacity	Costs, end 1976 dollars	
	Range	Average		Capital	Operating
8	<150	120	13.3	315,200	77,300
10	150 - 250	231	31.9	466,900	130,900
4	251 - 400	362	20.0	611,400	187,000
5	>400	503	34.8	768,800	243,200

The control technology behind these costs includes molecular sieve, mist elimination, and hydrogen cooling. The compliance schedule has been assumed to be 50 percent in 1975 and 50 percent in 1976.

Table A6.7.1 shows investment and annual costs for air-pollution controls for the mercury-cell segment of the chlor-alkali industry between 1970 and 1986.

Table A5.7.1. Mercury-cell chlor-alkali industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	0.0	18.81	0.0	0.0	14.14
TOTAL	0.0	18.81	0.0	0.0	14.14
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	3.06	10.72	9.18	18.37	26.44
TOTAL	3.06	10.72	9.18	18.37	26.44
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
NESHAPS	4.71	17.24	14.47	32.44	70.54
TOTAL	4.71	17.24	14.47	32.44	70.54
TOTAL ANNUAL COSTS	7.77	27.96	23.65	50.81	96.98

Chapter A5.8 Ammonia and Urea

Pollution control costs for ammonia and urea are considered together because both products are classified in SIC 2873, Nitrogenous Fertilizers, and virtually all establishments that manufacture urea also manufacture ammonia. Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars.

Regulations

Both ammonia and urea are included in a list of industrial categories for which new source performance standards (NSPS) are to be developed by EPA. Until such standards are promulgated, air-pollutant emissions can be controlled only by state regulations.

About two-thirds of the states in which ammonia is produced have regulations patterned after Appendix B (40 CFR, Part 51) or Los Angeles Rule 66. If hydrocarbon emissions are reduced by 85 percent, the sources are in compliance, regardless of the residual emission level. There is some question about the general applicability of these regulations to the manufacture of ammonia because methane, the only significant hydrocarbon emitted from the process, is excluded from some state regulations.

Only one state, New Mexico, has a regulation on ammonia emissions that is applicable to the synthesis of ammonia from natural gas or other hydrocarbon feed stocks. Less than 2 percent of the U.S. capacity for producing ammonia is located in New Mexico, and this regulation is not considered in this report.

Most of the states in which urea is manufactured have specific limitations on particulate emissions that are applicable to urea production. The regulations vary from state to state, but the most common limitation for a process weight rate of 40 tons per hour is for limitation of particulate emissions to 42.5 pounds per hour. Texas' regulations are the most liberal and California's South Coast regulations the most rigorous. For this report, it is assumed that all urea plants are subject to state regulations for particulate control.

Industry Characteristics

Ammonia is manufactured by the catalyzed reaction between hydrogen and nitrogen. The hydrogen is generally produced by the steam reforming of natural gas, which also produces carbon dioxide as a by-product. Urea is manufactured by the reaction of ammonia and carbon dioxide to form ammonium carbonate, and subsequent dehydration of this product to yield urea and water. Most urea plants are located in establishments that produce ammonia and carbon dioxide, but not all establishments that produce ammonia also produce urea.

There were 97 ammonia plants in the United States in 1977. Only the 67 plants that are located in states that are expected to have hydrocarbon-control regulations applicable to ammonia production by 1982 were used to derive model plant data. There were 48 urea plants in 1977, all of which were used in the determination of model plant sizes. Size ranges and average sizes of ammonia and urea plants are shown in Table A5.8.1.

The U.S. production of ammonia increased from 12.5 million metric tons in 1970 to 15.5 million metric tons in 1978. Continuation of the average rate of growth of production between 1972 and 1978 (2.45 percent per year, compounded) should give a production of about 20 million metric tons in 1988.

The U.S. production of urea increased from nearly 3 million metric tons in 1970 to nearly 5 million metric tons in 1978. The rate of growth between 1970 and 1978 (6.54 percent per year) continued to 1988 should lead to production of about 8.6 million metric tons that year.

It is estimated that about 90 percent of the production capacity for ammonia and 95 percent of that for urea is in establishments classified under SIC 2873. The remainder of the capacity for both chemicals is in various other SIC categories.

Pollutants and Sources

In the production of ammonia, a portion of the recycled synthesis gas is purged from the system to prevent the build-up of gases that are inert in the ammonia synthesis. The purge gas stream contains hydrogen, nitrogen, and ammonia, as well as the synthesis-inert argon and methane. Typical uncontrolled hydrocarbon (methane) emissions in the purge gas stream amount to about 45 kg/metric ton of ammonia.

In the production of urea, after urea has been formed in aqueous solution, unreacted ammonia and carbon dioxide gases are separated from the solution. All ammonia, and possibly carbon dioxide, is either recycled to the process or used in the production of liquid fertilizers.

About 40 percent of the urea produced is sold as a 70 percent urea solution, and is not a source of particulate emissions. The remaining 60 percent is concentrated in a crystallizer or an evaporator, then solidified. The solid urea is formed by either prilling or granulation. Particulate emissions may arise from the evaporator, prilling tower, granulator, product finishing, bagging and loading, and from bulk loading points. The prilling tower and granulator are alternative, not sequential, steps in the process. Average particulate emissions are estimated to be 3.5 kg/metric ton in prilling plants and 2.25 kg/metric ton in granulation plants.

Control Technology

Hydrocarbons and carbon monoxide in the purge gas from ammonia synthesis can be controlled by thermal incineration, without the use of

Table A5.8.1. Model plants for ammonia and urea production

	Number of plants	Capacity, 1000 Metric tons/year	
		Range	Average
Ammonia			
Small	28	less than 100	53
Medium	17	100-250	150
Large	22	more than 250	383
Urea			
Small	28	less than 100	49
Medium	13	100-200	152
Large	7	more than 200	306

significant fuel other than for a pilot light. Some ammonia producers already use the purge gas to supplement their fuel supplies.

Urea particulates for prilling and granulation plants can be controlled by the use of wet scrubbers.

Costing Methodology

Equipment costs for thermal incinerators without heat exchangers for specified gas flows and temperature differentials were obtained from vendors. Capital costs (installed costs) were obtained by multiplying equipment costs by 1.7. Operating and maintenance (O&M) costs were estimated by standard methods. The costs based on gas flow through the incinerator were related to ammonia production. Straight-line log-log relationships were calculated for capital and annual O&M costs for small plants and for medium and large plants.

It was necessary to make several assumptions before control costs could be estimated for urea plants. It was assumed that each plant sells only one type of urea product and 40 percent of the model plants sell urea solutions and 30 percent each sell prilled or granulated urea.

It was assumed that 400 pounds of air should be required to collect and transport one pound of urea particulate to a wet scrubber. This air is equivalent to about 41,500 acf (at 70 F)/metric ton of prilled urea and 26,680 acf/metric ton of granulated urea.

Capital and annual O&M costs for medium-efficiency wet scrubbers used with spray dryers in the soap and detergents industry were adapted for use with the urea industry. The value of recovered urea was subtracted from annual O&M costs.

Capital and annual O&M costs for air-pollution control of model ammonia and urea plants are shown in Table A5.8.2.

It is estimated that about 31 percent of existing ammonia capacity in small plants and 28 percent in medium and large plants will not come under state regulations for existing plants. Investment schedules for the remaining ammonia plants were prorated between 1975 and 1982.

About 50 percent of prilling urea plants and 80 percent of granulation plants were assumed to be using scrubbers for particulate control in 1977. The remaining plants were prorated to come into compliance by 1982.

Table A5.8.3 shows investment and annual costs for air-pollution controls for ammonia and urea production between 1970 and 1988.

Table A5.8.2. Control costs for model plants

	Number of plants	Average capacity 1,000 metric tons/year	Costs per plant, $1,000(a) Capital	Costs per plant, $1,000(a) Annual operating and maintenance(b)
Ammonia				
Small	28	53	292	29.8
Medium	17	150	362	33.6
Large	22	383	463	39.4
Urea Prilling				
Small	8	49	33.17	-6.02
Medium	4	152	60.61	-18.85
Large	2	306	87.98	-38.23
Granulation				
Small	9	49	26.22	-3.86
Medium	4	152	47.91	-12.08
Large	2	306	69.53	-24.48

(a) 1977 dollars for ammonia, 1973 dollars for urea.

(b) For urea plants, includes value of recovered urea.

Table A5.8.3. Ammonia and urea

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .961E+06

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	5.62	12.56	15.27	22.90	16.39
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	5.62	12.56	15.27	22.90	16.39
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	3.66	3.93	8.78	22.76	45.69
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	3.66	3.93	8.78	22.76	45.69
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	2.25	2.54	5.41	14.20	29.97
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.25	2.54	5.41	14.20	29.97
TOTAL ANNUAL COSTS	5.91	6.47	14.19	36.97	75.66

Chapter A5.9 Ammonium Nitrate Fertilizer

Ammonium nitrate is manufactured by reacting ammonia with nitric acid. About 85 percent of U.S. ammonium nitrate production is used as fertilizer, in either solid or liquid form. Essentially all of the remainder is used in explosives. Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

SIPs regulate particulate emissions from ammonium nitrate production. Most states rely on general process weight or stack gas concentration regulations. Appendix B (40 CFR 51, App. B) provides a process weight rate table of particulate limitations achievable with RACT. Pennsylvania is the only state with a regulation specifically limiting particulate emissions from ammonium nitrate production. No NSPS has yet been proposed for this industry.

Industry Characteristics

Ammonium nitrate is produced in solution, prilled, granulated, and crystalline forms. Of the 62 ammonium nitrate plants in the United States, 32 plants produce prills, six produce granules, and one produces crystals. One of these plants produces both prills and granules. Most also produce solutions, as well as 24 plants that produce only solutions.

Ammonium nitrate that is used as a fertilizer is classified in SIC 2873, whereas that used as an explosive is classified in SIC 2892. Most of the establishments that produce ammonium nitrate also produce other nitrogenous fertilizer materials. It is doubtful if more than 5 percent of ammonium nitrate production capacity is in establishments classified in SIC 2892.

Only the production of solid ammonium nitrate is important from the point of view of air-pollution control. The production of solid products decreased an average of nearly 3 percent per year between 1973 and 1978. This decline represented a reduction in the use of solid ammonium nitrate fertilizers, partially balanced by an increase in the use of ammonium nitrate explosives. Meanwhile, the use of ammonium nitrate solutions in fertilizer applications increased at about 3 percent per year during the same period.

Pollutants and Sources

Particulates from the drying and cooling of prilled and granulated products are the only emissions of significance in the manufacture of ammonium nitrate. It is standard industry practice in the prilling sector to collect such emissions and return them to the process.

Consequently, emission control costs are applicable only to the granulation sector, consisting of six plants.

Control Technology

Two-stage wet cyclconic scrubbers recommended for recovery of diammonium phosphate (DAP) particulates from process dryer vents should be equally satisfactory for the recovery of ammonium nitrate (AN) particulates from dryer and cooler vents.

Costing Methodology

It was assumed that the drying and cooling of DAP and AN would require about the same air flow per unit quantity of product. Therefore, cost functions determined for the control of DAP particulate with two-stage wet cyclonic scrubbers were applied to similar control of AN particulates. These cost functions were applied to two groups of AN model plants, as follows:

Number of plants	Capacity, 1000 metric tons/year	
	Range	Average
3	23-86	49
3	157-167	161

It is assumed that none of the six plants producing granulated ammonium nitrate was in compliance with state implementation plans in 1976, but all will be in compliance by 1982. The estimates of the cost of compliance are shown in Table A5.9.1.

Table A5.9.1. Ammonium nitrate fertilizer

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.11	0.10	0.28	0.43	0.27
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.11	0.10	0.28	0.43	0.27
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.05	0.02	0.11	0.32	0.69
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.05	0.02	0.11	0.32	0.69
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.08	0.04	0.18	0.53	1.02
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.08	0.04	0.18	0.53	1.02
TOTAL ANNUAL COSTS	0.13	0.06	0.29	0.84	1.70

Chapter A6. Metals Industries

For the purpose of this report, the Metals Industries have been defined as those establishments primarily engaged in refining, extracting, processing, fabricating, or recovering ferrous or nonferrous metals and processes performed by establishments in direct support of these operations. The industries included are:

- Iron and Steel
- Iron Foundries
- Steel Foundries
- Ferroalloy
- Primary Aluminum Smelting
- Primary Copper Smelting
- Primary Lead
- Primary Zinc Smelting
- Secondary Aluminum
- Brass and Bronze
- Secondary Lead Smelting
- Secondary Zinc

Costs associated with the control of air pollution by these industries are summarized in Table A6. These numbers are repeated below in the appropriate section together with discussion of the assumptions specific to the sector and other details.

TABLE A 6. METALS
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 6. 1	IRON & STEEL	195.00	1798.00	809.00	1980.00	2124.00
A 6. 2	IRON FOUNDRIES	14.61	381.19	48.74	81.52	110.70
A 6. 3	STEEL FOUNDRIES	11.55	89.18	33.92	55.42	78.94
A 6. 4	FERROALLOYS	0.0	206.65	0.0	0.0	0.0
A 6. 5	PRIMARY ALUM.	15.33	370.15	52.11	261.92	549.78
A 6. 6	PRIMARY COPPER	53.90	1926.30	161.70	342.10	387.40
A 6. 7	PRIMARY LEAD	0.0	3.15	1.05	10.28	27.39
A 6. 8	PRIMARY ZINC	0.0	20.95	8.41	8.41	11.29
A 6. 9	SECONDARY ALUM	1.88	24.11	8.87	15.22	34.07
A 6.10	BRASS &BRONZE	0.40	19.39	1.16	2.48	13.16
A 6.11	SECONDARY LEAD	0.0	13.18	4.15	97.08	139.39
A 6.12	SECONDARY ZINC	0.01	0.02	0.03	0.03	0.01
	TOTAL INVESTMENT	292.68	4852.27	1129.13	2854.46	3476.14

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 6. 1	IRON & STEEL	1212.75	3512.26	3353.98	8128.00	17330.83
A 6. 2	IRON FOUNDRIES	99.75	413.61	292.22	599.99	1053.80
A 6. 3	STEEL FOUNDRIES	27.58	47.79	74.75	169.60	339.33
A 6. 4	FERROALLOYS	50.63	224.06	151.88	303.76	467.72
A 6. 5	PRIMARY ALUM.	169.91	644.39	492.55	1038.28	1970.94
A 6. 6	PRIMARY COPPER	416.02	1844.68	1229.39	2465.64	3643.82
A 6. 7	PRIMARY LEAD	0.73	1.06	2.13	7.43	42.55
A 6. 8	PRIMARY ZINC	5.52	25.15	16.57	33.13	54.28
A 6. 9	SECONDARY ALUM	9.32	21.58	26.25	58.07	125.54
A 6.10	BRASS &BRONZE	4.79	12.88	13.32	28.15	49.83
A 6.11	SECONDARY LEAD	2.04	3.46	6.11	45.75	255.09
A 6.12	SECONDARY ZINC	0.02	0.02	0.05	0.11	0.24
	TOTAL ANNUAL COSTS	1999.05	6750.93	5659.20	12877.90	25333.94

Chapter A6.1 Iron and Steel

This chapter covers the air pollution control costs incurred by the iron and steel industry. The costs and text have been completely revised for this edition of the Cost of Clean Air Report.

Industry Characteristics

The iron and steel industry incorporates four major processes: iron ore mining, iron production, steel production, and steel finishing. Some iron and steel companies are fully integrated--with operations in all four process areas. Other enterprises manufacture iron (merchant blast furnaces), steel from purchased iron or scrap (e.g., minimills), or finished iron or steel, or are involved in a combination of these processes.

This chapter provides air pollution control costs both for integrated iron and steel plants and for enterprises operating at fewer than four stages of production, including minimills. Excluded are the mining stage, which has a relatively insignificant level of emissions, and iron and steel foundries, which are covered in Chapters A6.2 and A6.3.

The iron and steel manufacturing industry covered in this chapter is classified into SIC 3312 which includes blast furnaces (including coke ovens), steel works, and rolling mills. In 1977, there were a total of 504 establishments classified in SIC 3312, of which 35 were fully integrated, 99 were partially integrated, and 370 were engaged in only one level of production. The value of shipments was $42 billion in 1977 and $50 billion in 1980. Almost three-fourths of raw steel production and the associated value of industry shipments is produced in the five states of Pennsylvania, Ohio, Indiana, Illinois, and Michigan.

The production of raw steel fell from 137 million short tons in 1978 to 73 million short tons in 1982. The decrease is a result of import competition and the diminished demand for final goods that use steel, especially automobiles, construction, and machinery and equipment. In 1982 the steel industry was operating at about 50 percent of capacity, and many plants were closed. According to industry trade journals, there will be only a modest increase in production through 1984. It was assumed for this report that no new facilities will be constructed in the 1985 through 1990 period.

Emission Sources and Pollutants

The major sources of air pollution in the production of iron and steel are ore and coal yards, sintering plants, coke ovens, blast furnaces, steel making furnaces--open hearth, basic oxygen, and electric arc--and casting operations. Coal, iron ore, and limestone are the basic materials of iron and steel production. Coke ovens transform coal to coke, and sintering plants prepare a mixture of coke, iron, and limestone. A blast furnace then charges the mixture to produce molten pig iron. The hot molten iron, steel scrap, and flux materials are combined to form steel in either an open hearth (OH) furnace, a basic oxygen furnace (BOF), or an electric arc furnace (EAF). The raw steel product of these furnaces is then cast into basic steel forms such as billets, blooms, and slabs.

Ore and Coal Yards. The primary pollutant from ore and coal yards, where the iron ore and coal are transferred, prepared (crushed), and stored, is particulate matter in the form of dust. The emissions are a function of the material characteristics, the weather, and the method of handling and storing.

Sintering Plants. Sintering plants prepare a mixture known as sinter by crushing and combusting coke, breeze, fine iron ore, mill scale, flue dust, iron, and limestone. Particulates are emitted from the windbox and the discharge end of the sintering machine. Windboxes are compartments that collect particles from the downdraft of air, which passes through the mixture of materials to maintain combustion. At the discharge end of the machine, the sintered material is removed and conveyed to the blast furnace. Fugitive particulate emissions in the sintering building are created in the handling and grinding of the raw materials.

Coke Ovens. Coke oven batteries, which comprise a large set of ovens, generally produce coke for either blast furnaces or foundries. Both types of coke producers are included in this chapter.

Coke oven emissions arise from several processes or sources within the coke oven battery. Particulate matter is primarily emitted from (1) the charging operation, when the coal is charged into the coke ovens; (2) door and topside leaks, as the coal is transformed to coke; (3) the pushing process, when the hot coke is pushed from the oven to a quench car; (4) the quenching operation, when a direct spray of water cools the hot coke in a quench tower; and (5) the final skeleton and screening operation, where the cooled coke is broken down for further processing. The combustion stacks, door leaks, and topside leaks are other sources of particulate emissions. Sulfur dioxide and other volatile constituents such as benzene soluble organics, benzo-a-pyrene, and benzene are contained in the coke oven gases formed during the charging process. All coke ovens currently operating in the U.S. are by-product coke ovens, meaning that they have the capability of directing part of the gas stream to a by-product recovery plant. Benzene is the primary regulated pollutant of the by-product recovery plant.

Blast Furnaces. Emissions from the blast furnace occur during the transfer of materials into and out of the furnace. Particulate matter is generated when the raw materials are transported to the furnace. Gases and particulates in the form of iron oxides and flake graphite are emitted when the molten pig iron (slag) is removed or tapped from the furnace and processed.

Open Hearth Furnaces. The open hearth furnace is the oldest and least efficient of the three types of steel-making furnaces currently in operation. It requires additional fuel for refining the metals and a process time of from eight to twelve hours. In the past two decades it has been replaced with the other two furnace types. It produces an increasingly smaller proportion of raw steel than either other furnace type.

The primary pollutant from open hearth furnaces is particulate matter in the form of iron oxides. Particulate matter is emitted during the refining process, hot metal transfer, and slag processing. Fugitive particulate emissions also escape in the building. The flue gas from the refining process contains varying amounts of sulfur dioxide, nitrogen oxides, and fluorides, depending on the type of fuel used to charge the scrap, fluxes, and molten pig iron.

Basic Oxygen Furnaces. The basic oxygen process is a relatively new type of steel making process (first operated in the United States in 1955) that refines the mixture of steel scrap, hot metal, and flux without external heat and in a total process time of thirty minutes. A supply of pure oxygen reacts with the hot molten iron to refine the mixture. External iron desulfurization units are operated in conjunction with BOFs when the hot iron from the blast furnace has a higher sulfur content than can be processed in the BOF.

The BOF is less flexible than the other two types of furnaces because of its limitation on the percent of scrap that can be charged with the molten iron. Nevertheless, because of its greater efficiency relative to OH furnaces and greater capacity relative to EAFs, BOF furnaces produce a higher percentage of raw steel than the other two furnace types.

Particulate matter and carbon monoxide are the major BOF pollutants. Particulates are emitted from the refining process, hot metal transfer, charging and tapping, slag pouring, and slag processing. The BOF waste gases contain large amounts of carbon monoxide.

Electric Arc Furnace. In the electric arc furnace, a metallurgical reaction refines steel scrap and flux materials with heat generated from electrical currents. Because of its shorter processing time (about four hours) relative to the open hearth furnace, its proportion of raw steel production exceeds that of OH furnaces. Because EAFs do not depend on the molten pig iron from the blast furnace, they may be located near a supply source of scrap, where an integrated iron and steel plant would not be economical. Such installations are known as minimills. As with the other two types of furnaces, particulate matter is the primary pollutant during refining, slag pouring, and slag processing. Carbon monoxide is also generated during the refining cycle.

Casting. There are two types of casting processes: ingot casting and continuous casting. Ingot casting involves pouring raw steel from a steel furnace into ingot molds. After the ingots are cooled and stripped from their molds, they are reheated in soaking pits and rolled into blooms, billets, or slabs in a primary mill. This process leaves defects on the surface, which are removed by the scarfing process. The hot scarfing machine burns the surface of the steel with a jet of oxygen combined with a fuel gas.

Continuous casting is the forming of blooms, billets, or slabs directly from the hot raw steel produced by a steel-making furnace. It is a more efficient system than ingot casting, because the rolling steps are eliminated and the scarfing steps are greatly reduced. Continuous casting has become the predominant casting process since its introduction into the United States in the 1960's.

Particulate matter is the primary pollutant from both casting processes. In this report, ingot pouring and reheating are included in the hot metal transfer operation that is part of the steel-making process, and scarfing is considered a separate primary emissions source in the casting process.

Regulations

The primary air pollution regulations covering the integrated iron and steel industry are SIPs and two NSPS. One NSPS regulates basic oxygen process furnaces and the other, electric arc furnaces.

The NSPS for BOFs was promulgated March 8, 1974 (40 CFR 60.140). It provides standards for primary particulate emissions and opacity. In response to the most recent review of these standards, EPA has proposed a revision to this NSPS and an additional NSPS to regulate secondary particulate emissions (48 FR 2657, January 20, 1983).

The NSPS for EAFs was promulgated September 23, 1973 (40 CFR 60.270). It sets particulate matter and opacity limits on emissions from control devices on EAFs and opacity limits on emissions from EAF shops and dust-handling equipment.

The general process weight rate limits for particulate matter suggested as achievable with RACT in Appendix B (40 CFR 51) apply to iron and steel sources. Similar limits for general process industries found in most SIPs cover the iron and steel industry. Of the five states where the bulk of the industry is located, Illinois, Michigan, and Pennsylvania establish limits for specific process categories in iron and steel manufacturing.

Appendix B and most states do not set sulfur dioxide limits for process emissions in this industry. Indiana, Ohio, Pennsylvania, West Virginia, New York, and Kentucky set limits on sulfur dioxide (in the form of hydrogen sulfide) from by-product coke ovens. Although Appendix B suggests complete secondary combustion of waste gases as a means of controlling carbon monoxide from blast furnaces and basic oxygen steel furnaces, most states did not adopt this as a requirement.

The SIPs of most states with iron and steel plants have been recently revised. Promulgation of the revised SIPs has been delayed beyond the originally scheduled 1979 date. This delay has served to extend the compliance dates for iron and steel sources.

In response to requests by the iron and steel industry for compliance extensions, Congress amended Section 113 of the Clean Air Act by enacting the Steel Industry Compliance Extension Act (SICEA) in July 1981. This act, known as the steel stretch-out act, provides for negotiations between steel companies and EPA to determine extensions of installation deadlines. Such extensions apply to certain capital intensive air pollution control equipment for a maximum of three years on a case-by-case basis. SICEA allows extensions only if the funds that would have been required to meet an existing compliance schedule are invested in other capital improvements.

EPA's "bubble policy" has been applied to the iron and steel industry. This policy allows tradeoffs in emissions among stack and fugitive emission sources within a plant site and effectively bases compliance on the entire plant rather than on individual sources. Bubble approvals have been incorporated into renegotiated consent decrees with individual plants.

Two NESHAPs are under development for this industry. One would regulate benzene emissions from coke oven by-product recovery plants and the other, coke oven emissions from by-product coke oven charging, door leaks, and topside leaks.

Control Technologies

Table A6.1.1 presents a summary of the control technologies by emissions source that are assumed as the basis for cost estimates in this report. It also reports the percentage of the controlled sources estimated to employ each technology in 1981. If uncontrolled (as of 1981) sources are expected to use a significantly different mix of control technologies, the percentage of such sources expected to employ the respective technology in the period from 1981 through 1990 is also provided in parentheses.

Electrostatic precipitators (ESPs), scrubbers, and fabric filters (baghouses) are installed in various combinations on most of the particulate emitting sources. These include sintering plants, coke oven pushing operations, coke oven combustion stacks, coke handling, blast furnaces, all three types of steel furnaces (OH, BOF, and EAF), external iron desulfurization facilities, and scarfing plants. Canopy hoods, enclosures, and evacuation systems are accessory controls to capture fugitive emissions from many of the facilities. Evacuation systems in particular are installed on a large percentage of blast furnaces and electric arc furnaces.

Simple water sprays and dust suppression are sufficient to control the particulate dust in the ore and coal yards. The control

Table A6.1.1. The distribution of control technologies by process

Process	Applicable control technology	Percent of sources using control*	
ORE YARDS	Water sprays and dust suppression	100	
COAL YARDS	Water sprays and dust suppression	100	
SINTERING			
1) Windbox	a) Wet ESP	40	
	b) Venturi scrubber	35	
	c) Combination, ESP with baghouse or scrubber	11	
	d) Baghouse	7	
	e) Other (cyclones, gravel bed filter)	7	
2) Discharge and Fugitive Building	a) Canopy hood with baghouse	50	
	b) Rotoclones and multiclones	25	
	c) Scrubbers	25	
COKE OVENS			
1) Charging	a) Stage charging, modified larry car	46	
	b) Stage charging, new larry car	47	
	c) Pipeline charging with ESP or scrubber	7	
2) Pushing	a) Enclosed hot car with scrubber	60	(0)
	b) Bench mounted hood with scrubber or baghouse	20	(0)
	c) Traveling hood with scrubber or baghouse	10	(50)
	d) Coke-side shed with ESP, scrubber or baghouse	10	(50)
3) Quenching	a) Diverted flow tower, baffles, clean water	7	
	b) Conventional tower, baffles, clean water	42	
	c) Conventional tower, baffles, dirty water	51	
4) Combustion Stacks	a) Dry ESP	60	(20)
	b) Baghouse	40	(0)
	c) Oven patching	0	(80)
5) Coke Oven Gas	a) Desulfurization	100	
6) Coke Oven Doors	a) Door cleaning and maintenance	65	
	b) New doors with cleaning and maintenance	35	

Continued..

Table A6.1.1. (Continued)

Process	Applicable control technology	Percent of sources using control*	
7) Coke Handling (Screening)	a) Canopy hood with baghouse	100	
BLAST FURNACES			
1) Casthouse	a) Taphole hood evacuation with baghouse b) Total evacuation with baghouse	60	(0)
	c) Nonevacuation techniques	40	(100)
OPEN HEARTH FURNACES			
1) Refining	a) Dry ESP	40	
	b) Scrubbers	30	
	c) Combination, ESPs and scrubbers	30	
2) Hot Metal Transfer	a) Canopy hood with baghouse	100	
EXTERNAL IRON DESULFURIZATION	a) Baghouse	100	
BASIC OXYGEN FURNACES			
1) Refining	a) Open hood with dry ESP	45	
	b) Closed hood with scrubber	25	
	c) Open hood with scrubber	30	
2) Hot Metal Transfer	a) Canopy hood with baghouse	100	
3) Charge and Tap	a) Gaw damper	15	(0)
	b) Furnace enclosure with baghouse	5	(100)
	c) Canopy hoods, tapping enclosures, etc.	80	(0)

Continued...

Table A6.1.1. (Continued)

Process	Applicable control technology	Percent of sources using control*
ELECTRIC ARC FURNACES		
1) Refinery (including fugitives)	a) Direct evacuation, canopy hood with baghouse	30
	b) Direct evacuation with baghouse, scrubber or ESP	15
	c) Canopy hood, building evacuation with baghouse	25
	d) Other variations	30
PRIMARY BREAKDOWN (SCARFING)		
1) Billets	a) Wet ESP	100
2) Blooms and slabs	a) Wet ESP	45
	b) Scrubbers	30
	c) Baghouse or rotoclones	5
	d) Water spray tunnel	20

SOURCE: GCA Corporation, Reconciliation of Estimates of Investments by Iron and Steel Industry in the Pollution Control Equipment, (EPA Contract No. 68-01-6316), March 1983, Tables 4-7, pp. 43-44.

*The percent of sources with controls installed as of 1981. This historical distribution is assumed for the forecast period unless a parenthetical number appears. In these exceptions, the number in parentheses represents the percent of sources uncontrolled as of 1981 that are expected to employ the respective technology in the future. The estimated compliance schedule is described in the test.

assumed in coke oven charging is use of the more efficient stage charging technique and a more efficient new or modified larry car to prevent fugitive emissions when the coal is charged into the ovens. The baffles installed as controls on the quenching towers of coke ovens are capture devices that prevent emissions from escaping. The desulfurization unit installed to control the hydrogen sulfide in the coke oven waste gases is assumed to include a vacuum carbonate plant and a Claus plant for sulfur recovery.

Cost Methodology

Total costs of control are presented by year in Table A6.1.2. The costs for the control technologies outlined in Table A6.1.1 were taken from a study performed for EPA by GCA Corporation (Reconciliation of Estimates of Investments by Iron and Steel Industry in Air Pollution Control Equipment Final Memorandum, March 1983, EPA Contract No. 68-01-6316). The costs are based primarily on cost curves developed by PEDCo Environmental, Inc. Historical costs (1970 through 1981) were derived by applying these cost curves to GCA's data base of iron and steel facilities and installed control devices. Forecast costs (1982 through 1990) were derived by applying these cost curves to controls expected to be installed in the future as estimated by EPA Regional Office engineers, taking into account slow industry recovery, the steel stretchout act, and existing bubble approvals.

Compliance assumptions for each source type differ for stack and fugitive emission controls. Compliance with stack emission regulations in 1981 was estimated to be 30 percent for sintering plants, 50 percent for coke ovens, 60 percent for OH furnaces, 75 percent for BOFs, 95 percent for EAFs, and 60 percent for scarfing operations. Full compliance with stack emission regulations is assumed to be achieved by 1985 for all operations.

For fugitive emission controls, compliance levels in 1981 were estimated to be 25 percent for ore and coal yards, 40 percent for sintering plants, 20 percent for coke ovens, 5 percent for blast furnaces, 20 percent for OH furnaces, 35 percent for BOFs, 90 percent for EAFs, 100 percent for continuous casting operations, and 85 percent for scarfing operations. Compliance with fugitive emission regulations is assumed to be complete by 1985 for all operations.

Table A6.1.2. Iron and steel

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	195.00	1798.00	809.00	1980.00	2124.00
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	342.75	957.26	943.98	2361.01	4979.84
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	870.00	2555.00	2410.00	5767.00	12351.00
TOTAL ANNUAL COSTS	1212.75	3512.26	3353.98	8128.01	17330.84

Chapter A6.2 Iron Foundries

This chapter describes the iron foundry industry and presents estimates of the costs of particulate and carbon monoxide emission control for gray iron cupolas and particulate emission control for electric arc furnaces in iron foundries. This revision of the iron foundries chapter incorporates updated industry information, revised furnace population data, cost estimates for carbon monoxide control, and new cost estimates for electric arc furnace controls.

Industry Characteristics

Iron foundries are part of the foundry industry, which produces castings: metal molds, pipes, and a wide variety of specialized forms and parts. The foundry industry is subdivided into ferrous (iron and steel) and nonferrous (copper, aluminum, zinc, and other) metal foundries.

Iron foundries may be categorized by their production of gray iron, ductile iron, or malleable iron castings, although many ferrous foundries cast more than one metal. If foundries are defined by the major metal cast in each, there were 1,343 gray and ductile iron foundries and 53 malleable iron foundries in 1980. Gray iron was cast in a total of 1,461 foundries; ductile iron, in 643; and malleable iron, in 110.

In 1980, 44 percent of all iron foundries were small operations, having fewer than 50 employees. Only 13 percent employed 250 or more. The number of very small foundries is declining over time. They are being replaced by additional capacity in new and existing larger foundries.

Iron foundries are located in almost every state, but more than half are concentrated in the Great Lakes and Mid-Atlantic regions - in the iron and steel producing areas and near the major markets for industrial castings. Many of the larger iron foundries are captives, producing metal parts for the parent company's end products. In 1976, 40 percent of iron foundries were captive, while 60 percent were exclusively jobber (all their tonnage was sold on the open market). Of the captive foundries, 62 percent sold at least some castings in the open market.

Demand for iron castings is characterized by cyclical fluctuations. Total shipments of iron castings were 12.2 million tons in 1980, down from an average of 15.5 million tons per year for the 1975-1979 period.

Gray iron shipments totalled 9.4 million tons in 1980. About 32 percent of that tonnage was in ingot molds and in pipe and fittings. The top three markets for the remaining industrial castings are automotive, farm machinery, and engine manufacturers.

Ductile iron shipments were 2.4 million tons in 1980. Ductile iron casting is the newest and fastest growing segment of the iron foundry industry. Many gray iron and some malleable iron foundries are adding ductile iron casting capabilities. About 40 percent of ductile iron shipments are pressure pipes. Other important markets for ductile iron are the automotive and farm equipment industries.

Malleable iron shipments totalled 450 thousand tons in 1980. Malleable iron's position in the industry is minor and declining. Historically, the automotive industry has used 75 percent of malleable iron tonnage, but ductile iron has proven a superior substitute for malleable iron in many automotive applications.

Demand for iron castings may increase to historic levels as the current recession ends, assuming improvement in the domestic automobile market. Only slight additional growth is expected for gray iron. Demand for ductile iron should increase more rapidly, and demand for malleable iron is expected to continue to decline. There is some excess capacity in the industry (capacity utilization for gray iron foundries was 83 percent in 1979 and 76 percent in 1981), and the trend to replace smaller foundries with larger ones tends to result in more efficient capacity utilization. Thus, it was assumed that there will be no net melting capacity increase in the remainder of the 1980's.

Gray and ductile iron foundries are classified in SIC 3321; malleable iron foundries are in SIC 3322. The reported value of shipments for gray and ductile iron foundries was $7.4 billion in 1977; malleable iron shipments were valued at $722 million. Many captive foundries are departments of manufacturing operations and are not included in SICs 3321 and 3322. They are included in other SICs such as 371 (motor vehicles and equipment), 355 (industrial machinery), and 352 (farm and garden machinery).

Emission Sources and Pollutants

Iron foundries produce iron castings through the following series of distinct operations: raw materials storage and handling, pattern making, sand preparation, mold making, core making, melting, pouring, cooling, shakeout, and cleaning and finishing.

The majority of emissions is produced by the melting process in foundry furnaces. The level of melting emissions depends on furnace design, charging practice, quantity and quality of charged materials, and melting zone temperature. Also important are the quantity of coke used, the volume and rate of combustion air, and the use of techniques such as oxygen enrichment and fuel injection (cupola furnace only).

Four types of furnaces are used in iron foundries: cupola, electric arc, electric induction, and reverberatory. About 70 percent of all foundry iron is produced in the cupola furnace because of its flexibility in handling different types of scrap and its low energy consumption. Cupola emissions include carbon monoxide, particulates, and oil vapors. Particulate emissions amount to approximately 17 pounds per ton of iron melted per hour. They arise from dirt on the metal charge and from fines in the coke and limestone charge. Carbon monoxide and hydrocarbon emissions arise primarily from partial combustion and/or distillation of oil from greasy scrap charged to the furnace.

In electric arc furnaces, electrodes are placed into the charge of the vessel and an electric arc between the electrodes and the charge generates the heat required to melt the metal. The high temperature arcs produce dense fumes consisting of iron and other metal oxides plus organic particulates from oil and other contaminants in the scrap. These furnaces produce approximately 14 pounds of particulates per ton of iron charged.

Electric induction furnaces are used for melting iron where high quality, clean, dry, grease-free metal is available for charging (reducing explosion potential). Because of the high quality of the material charged to induction furnaces, particulate emissions are only from 0.1 to 1.5 pounds per ton of iron charged per hour.

Reverberatory furnaces in large facilities are used to provide additional refining and super heating prior to pouring. They are used for melting in very small facilities (capacities less than two tons). These furnaces produce relatively few emissions.

Many other operations in the foundry produce particulates and gases that create significant fugitive emission control problems. The core making operation produces particulate and hydrocarbon emissions. Sand preparation, molding, and finishing produce dust (dirt, sand, metal pieces). The casting shakeout process generates dust and gases (sand, dirt, metal pieces, metal vapors). Gaseous emissions (metal oxide gases, oil vapors) result from pouring melted metal into molds.

This chapter only includes control cost estimates for cupolas and electric arc furnaces. Adequate cost estimates for fugitive controls in iron foundries were not available.

Regulations

There are no NSPS for the iron foundry industry. State air pollution control regulations include limitations on emissions of particulate matter and carbon monoxide from iron foundry operations.

Particulates. General industrial process weight rates or concentration limitations usually govern iron foundry particulate emissions. In addition, foundries must meet opacity standards, except in areas where existing cupolas are exempt from the limitations. Foundry operations are also increasingly subject to fugitive emission control standards as these requirements are adopted by more and more states.

Several states have separate regulations that apply specifically to iron foundry cupolas. For existing gray iron cupolas, these regulations are often less stringent than the general industrial limitations. Some states also distinguish between gray iron jobbing cupolas and production foundries. (Jobbing cupolas have a single melt cycle and are operated on a job-by-job basis, usually only a few hours per day. Production cupolas are characterized by continuous melting and may operate eight to twenty-four hours per day.) Specific limitations for jobbing cupolas are less stringent than those for production cupolas.

Carbon Monoxide. State regulations for cupolas located in carbon monoxide nonattainment areas and in regions where carbon monoxide controls are needed to maintain air quality are often patterned after the RACT suggested in Appendix B (40 CFR 50). Appendix B states that carbon monoxide emissions in the waste gases of gray iron cupolas can be limited by complete secondary combustion.

Lead. Several states have identified iron foundries as lead point sources in preparing their lead SIPs. However, very few foundries are expected to require additional control to meet ambient lead standards, since iron foundry lead emissions are usually adequately controlled by existing particulate collection devices.

Control Techniques

Fabric filters and wet scrubbers are the devices most frequently used to reduce particulate emissions from cupolas. Afterburners are also installed when carbon monoxide control is required. The cupola gases are incinerated in the afterburner. The hot gases leaving the afterburner are cooled, usually in either a quencher or an evaporative cooler, before going into the particulate collector. The choice of the cooling device depends somewhat on the type of collector used. For example, quenchers would not be used with fabric filters since the resulting moisture would damage the bags.

The cost estimates in this chapter are based on evaporative coolers and fabric filters for small and medium sized cupolas and quenchers and wet scrubbers for large cupolas. These controls allow compliance with SIP limitations on particulate emissions. Medium efficiency scrubbers are costed for existing (pre-1972) large cupolas while high efficiency scrubbers are costed for newer large cupolas.

Control of electric arc furnace emissions is accomplished in two steps: (1) collection and evacuation of the exhaust gas and (2) removal of particulates from the collected gas. Side draft hoods are commonly used as exhaust gas collection devices. Fabric filters are the only particulate removal devices commonly used on electric arc furnaces in the United States.

The combination of a side draft hood and fabric filter provides sufficient control to meet the process weight regulations and visible emission limitations found in typical state pollution control regulations. Use of these devices is assumed as the basis for the cost estimates for electric arc furnace controls.

It was assumed that 75 percent of cupolas and electric arc furnaces were in compliance with SIP requirements by the end of 1976, 90 percent complied by the end of 1978, and 100 percent complied by the end of 1982. This assumption was based on summary reports for gray iron foundries from EPA's Compliance Data System for 1980 and earlier years.

Costing Methodology

Model plant cost data from previous EPA studies were used to develop capital and O&M cost functions for the quencher/scrubber and evaporative cooler/fabric filter systems used with cupolas. Similar data sources were also used for the side draft hood/fabric filter systems used with electric arc furnaces. Capital and O&M cost functions were estimated separately for cupola afterburners, since afterburner costs were not included in the model plant cost data for cupola controls.

Capital and O&M costs are expressed as functions of the melting capacity (in tons per hour) of individual furnaces. Thus, total industry costs were based on estimates of the numbers and capacities of cupolas and electric arc furnaces in iron foundries (not on the number of foundries).

Note: Costs labeled "NSPS" in Table A6.2.1 are actually SIP compliance costs for new furnaces installed in 1972 and later. Costs labeled "SIP" are for furnaces existing in 1971.

Table A6.2.1. Iron foundries

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .411E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	7.36	342.39	27.95	36.84	20.57
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	7.25	38.80	20.79	44.69	90.14
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	14.61	381.19	48.74	81.53	110.70
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	43.84	184.72	128.93	262.30	442.10
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	7.01	17.42	18.50	45.04	115.69
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	50.85	202.14	147.43	307.33	557.79
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	42.78	195.70	128.51	253.50	398.37
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	6.13	15.76	16.28	39.16	97.65
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	48.91	211.47	144.79	292.66	496.01
TOTAL ANNUAL COSTS	99.75	413.61	292.22	599.99	1053.80

Chapter A6.3 Steel Foundries

This chapter presents costs for particulate emission controls for electric arc furnaces in steel foundries. The chapter revision included expanding the discussions of industry characteristics and of emission sources, reorganizing and rewriting the entire chapter, and removing the NSPS costs that were included in the most recent edition of this report.

Industry Characteristics

In 1980, 637 U.S. foundries produced steel castings. Steel was the principal metal cast in approximately 450. During the 1970-1979 period, annual steel casting production averaged 1.8 million tons. There was cyclical variation in the annual production figures but no apparent net growth. The total number of foundries producing steel castings increased by 15 to 20 percent during that period. At the same time, the total number of electric arc and induction furnaces (in all foundries) increased by approximately 30 percent. These statistics may explain the drop in steel foundry capacity utilization from 90 percent in 1974 when 2.09 million tons were produced to 82 percent in 1979 when a comparable 2.04 million tons of castings were produced. Capacity utilization averaged 76 percent during the 1977-1981 period.

Two types of steel are produced by steel foundries: carbon steel castings and alloy steel castings. During the 1970's, carbon steel constituted approximately two-thirds of total steel foundry shipments. Carbon and low alloy castings together made up over 90 percent of steel castings production. The following industries provide the most important markets for carbon and low alloy steel castings: railroads, construction, mining, materials handling, and metal working equipment. The remainder of steel castings production is high alloy. The principal users of these castings are the construction industry, machinery manufacturers, and the motor vehicles industry.

Steel foundries generally use electric arc and/or induction furnaces for melting. In 1976, approximately 80 percent of steel foundries had melting capacity less than 10 tons per hour.

Emission Sources and Pollutants

Steel foundries produce castings through the following series of distinct operations: raw materials storage and handling, pattern making, sand preparation, mold making, core making, melting, pouring, cooling, shakeout, and cleaning and finishing.

This chapter includes control cost estimates only for electric arc furnaces. The furnace processes generally create the majority of foundry emissions although there are other foundry operations that produce particulate and some gaseous emissions. For example, the core making operation produces particulate and hydrocarbon emissions. Sand preparation, molding, and finishing produce dust (dirt, sand, metal pieces). The casting shakeout process generates dust and gases (sand, dirt, metal pieces, metal vapors).

Electric arc and electric induction are the furnace types most commonly used in steel foundries. Emissions from electric induction furnaces are usually low (approximately 0.1 pounds per ton), requiring little control. Particulate emission rates from uncontrolled electric arc furnaces in steel foundries average about 16 pounds per ton for melting and refining and about 1.6 pounds per ton for charging and tapping. Emissions vary considerably from furnace to furnace, depending on the furnace type and age, kinds of scrap processed, additives to the melt, and the types of steel products produced. In addition, significant increases in emission rates occur during backcharging and oxygen lancing.

Regulations

There are no NSPS for steel foundries. The NSPS developed for electric arc foundries in ferrous foundries has been withdrawn.

Steel foundry operations are regulated under SIPs. A few states provide particulate limits specifically for electric arc furnaces. In most states, however, steel foundry particulate emissions regulation is accomplished under general industrial process weight rates or concentration limitations. In addition, foundries must meet opacity standards, and foundry operations are also increasingly subject to fugitive emissions control requirements.

Control Techniques

Control of electric arc furnace emissions is accomplished in two steps: (1) collection and evacuation of the exhaust gas and (2) removal of particulates from the collected gas. Fabric filters are the only particulate removal devices commonly used on electric arc furnaces in the United States. Direct furnace evacuation is commonly used to collect emissions from steel-making electric arc furnaces. Side draft hoods are also used as collection devices, especially for small steel furnaces which often cannot support direct evacuation.

The combination of direct evacuation (for medium and large furnaces) or side draft hood (for small furnaces) and fabric filter is assumed as the basis for the cost estimates for electric arc furnace controls. Use of these devices provides sufficient control to meet the process weight regulations and visible emission limitations found in typical state pollution control regulations.

Costing Methodology

The control costs shown in Table A6.3.1 are based on model plant cost data from the May 1980 draft NSPS document, "Electric Arc

Furnaces in Ferrous Foundries - Background Information for Proposed Standards." Capital and O&M cost functions were estimated by linear regression of the logarithms of the cost and capacity variables for the "baseline" control alternative in the document. These functions were derived separately for small steel furnaces (using side draft hoods) and for medium/large furnaces (using direct evacuation).

Capital and O&M costs are expressed as functions of the melting capacity (in tons per hour) of individual furnaces. Thus, total industry costs were based on estimates of the number and capacities of electric arc furnaces in steel foundries (not on the number of foundries).

Note: Costs labeled "NSPS" in the table are actually SIP compliance costs for new furnaces installed in 1973 and later.

Table A6.3.1. Steel foundries

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .197E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	6.19	72.25	18.57	24.76	29.09
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	5.36	16.93	15.34	30.66	49.84
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	11.55	89.18	33.92	55.42	78.94
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	11.94	21.71	33.38	71.64	126.24
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.24	6.39	10.65	27.64	69.61
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	16.18	28.10	44.03	99.29	195.86
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	7.60	13.97	21.19	45.57	80.74
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	3.80	5.72	9.53	24.74	62.74
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	11.39	19.69	30.72	70.31	143.48
TOTAL ANNUAL COSTS	27.58	47.79	74.75	169.60	339.33

Chapter A6.4 Ferroalloy Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

NSPS were promulgated for ferroalloy production facilities on May 4, 1976 (40 CFR 60.260), and revised in 1976 and 1977. These standards cover particulates, carbon monoxide, and plume opacity from electric submerged arc furnaces and plume opacity of dust handling equipment.

Unlike most of the metal industries' facilities, ferroalloy production is not identified as a major stationary source subject to special review for BACT or BART. Thus, ferroalloy facilities must have 250 tons per year of potential emissions before they may be required to meet BACT requirements.

Most SIPs include particulate standards patterned after the process weight tables suggested as RACT standards in Appendix B (40 CFR 51, App. B). Pennsylvania is the only state that has a limitation specifically for ferroalloy production furnaces.

Industry Characteristics

Ferroalloys are made by two methods, electric furnace smelting and metallothermic reduction. Until a few years ago, two integrated steel companies produced high carbon ferromanganese in blast furnaces. These operations are now closed. Submerged electric arc furnaces are used for making the majority of ferroalloys in the United States. These furnaces are of three types, (1) open furnaces, (2) semicovered furnaces, and (3) sealed furnaces.

Open furnaces are equipped with hoods. The "open" description concerns the vertical opening around the furnace extending from the charging floor to the bottom of the hood. This opening is required in the production of certain ferroalloys because crusts tend to form on top of the charge. The crust must be broken with mechanical equipment for proper furnace operation.

Semicovered furnaces are equipped with water-cooled hoods to collect emissions. The charge material is fed to the furnace through openings around the electrodes. Charging through the hood permits a reduction in the height of the opening around the furnace.

Sealed furnaces are completely sealed to prevent the escape of emissions and to minimize the influx of air.

Ferroalloy production by the metallothermic reduction route is quite small and tends to produce speciality ferroalloys rather than tonnage alloys. Seven companies make ferroalloys by this procedure. Because there is insufficient information on metallothermic plants as to number of furnaces, emissions, and air-pollution control methods, those plants have been included with electric furnace plants in estimating control costs.

Industry Structure. At the end of 1976, 32 companies were operating 54 plants to produce ferroalloys. Ten of these plants produced ferrophosphorus, seven used the metallothermic process, and the rest operated electric furnaces.

Over the past decade the number of furnaces with a power rating of less than 10 megawatts has decreased drastically, while the number of furnaces having 20 or more megawatts in power has increased significantly. This illustrates the trend in the industry toward closing the small, inefficient furnaces and replacing them with larger, more efficient units.

During 1978, Airco, Inc., closed its ferromanganese plant at Theodore, Alabama. This plant has been purchased by Autlan, a Mexican producer, and the plant will restart. Airco recently sold its Charleston, S.C. plant to a new firm, Macalloys Inc., and its Niagara Falls and Calvert City plants to SKW, a German firm. The three plants will continue to operate.

The largest consumption of ferroalloys, by far, is in the production of steel and iron alloys. Therefore, the future production and consumption of ferroalloys will depend almost entirely on the production of raw steel and cast iron. Over the past 10 years or so, imports of ferroalloys have increased essentially annually, especially for manganese and chromium alloys. Foreign countries have expanded their ferroalloy capacity and production in order to export their products to the large steel-producing nations. Some of these new foreign ferroalloy plants are partially owned by American companies. This situation, along with certain domestic problems, obviously has deterred present ferroalloy producers from expanding their capacity in this country. Therefore, imports probably will continue to provide an ever increasing share of ferroalloy consumption in the United States to the detriment of the domestic industry.

Pollutants and Sources

Particulate emissions are generated during the handling of ores, fluxes, and reductants used in the production of ferroalloys. Particulate and gaseous emissions are continuously evolved during the smelting operations. These emissions occur at the top of the furnace, at the taphole intermittently, and at the ladle after tapping. Particulate emissions are composed of oxides of the metals being produced and used in the process.

The water emissions occur only when a wet scrubber is used for pollution control. The slurry is settled, filtered, and treated. The water is returned to the furnace as a coolant and the filter cake is dumped.

Control Technology and Costs

Baghouses, electrostatic precipitators, and high-energy scrubbers are all used to control emissions from submerged arc electric furnaces. Baghouses are preferred, while electrostatic precipitators are seldom used.

A total of 126 ferroalloy furnaces was used in developing cost estimates. Those furnaces that were not identified as having specified control systems were prorated so that the totals were in the same proportion as the 66 baghouses and 39 scrubbers that were identified. There are only two furnaces with electrostatic precipitators. Costs were estimated on the basis of control equipment air flow, or if that information was unavailable, on the basis of furnace megawatt rating.

Control costs are summarized in Table A6.4.1.

Table A6.4.1. Ferroalloy industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .188E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	206.65	0.0	0.0	0.0
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	27.17	115.43	81.51	163.02	233.14
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	23.46	108.63	70.37	140.74	234.57
TOTAL ANNUAL COSTS	50.63	224.06	151.88	303.76	467.72

Chapter A6.5 Primary Aluminum Smelting

Revision of this chapter was limited to updating the pollution control costs to 1981 dollars and rewriting the discussion of applicable regulations.

Regulations

The NSPS for primary aluminum reduction plants, which was promulgated on January 26, 1976 (40 CFR 60.190), set standards for fluoride emissions and opacity. Since fluoride is a designated pollutant, EPA's promulgation of NSPS for aluminum reduction plants forces states to include in their SIP revisions a fluoride standard for all existing aluminum reduction plants. EPA issued guidelines to the states for development of these standards in December 1979. Fluoride standards for existing aluminum reduction plants need not be as stringent as the NSPS since the emissions are considered to be "welfare-related" rather than "health-related."

Six states (Alabama, Louisiana, Montana, Nevada, Oregon, and Washington) have had particulate emission standards for primary aluminum plants for several years. Other states have general particulate standards that apply to primary aluminum plants, which are patterned after the particulate process weight table of Appendix B (40 CFR 51, App. B).

Industry Characteristics

The domestic primary aluminum industry includes approximately 10 companies operating reduction facilities in 16 states. Three companies operate about two-thirds of the total capacity. The largest 50 percent of the plants constitute about two-thirds of industry capacity. Plants tend to be located in areas where low-cost electrical power is available.

Aluminum is one of the most abundant elements and when measured either in quantity or value, its use exceeds that of any other primary metal except steel. It is used to some extent in virtually all segments of the economy, but its principal uses have been in transportation, building construction, electrical industry, containers, packaging, consumer durables, machinery, and equipment. The annual growth rate of aluminum production in the United States has averaged 7 percent in recent years.

Bauxite ore (typically containing 50-55 percent alumina) is the principal source of aluminum. Alumina is extracted from bauxite by one of the variations of the Bayer process. In turn, alumina is dissolved in molten cryolite and reduced to aluminum by electrolysis in the universally used Hall-Herould aluminum reduction cells, which are connected in series to form a potline.

The aluminum reduction plant may be classified according to the type of anodes used in the cells. Prebaked anodes are replaced intermittently, and Soderberg anodes are replaced continuously. In the Soderberg continuous system, an anode paste is continuously supplied to a rectangular metal shell suspended above the cell. As the anode shell descends, it is baked by the heat of the cell. Two types of Soderberg anodes use different support methods: a vertical stud system supported on vertical current-carrying pins (studs), and a horizontal stud system supported by pins which are inclined slightly from the horizontal.

Pollutants and Sources

All three anode systems used to produce aluminum release particulates and fluorides (in both gaseous and particulate form) which must be controlled.

Of the three anode systems in use, the vertical Soderberg system emits the lowest quantity of particulates. The prebaked and horizontal Soderberg systems are higher in pollutant emissions. On the other hand, the emissions from the prebaked system are easiest to control, those from the vertical Soderberg are somewhat more difficult, and those from the horizontal Soderberg the most difficult to control. This has led to a gradual phasing out of the latter two processes.

The principal sources of emissions at primary aluminum smelters are the electrolytic cells and, in the case of prebake-anode type plants, the anode bake furnace. The raw, uncontrolled rates of emissions from these processes have been identified as averaging 25 kg per metric ton (50 pounds per short ton) of fluorides and 56 kg per metric ton (112 pounds per short ton) of particulates per ton of aluminum produced.

Control Technology

In this analysis, it was assumed that all sources would be controlled to a standard allowing emissions of one kilogram of fluoride per metric ton (two pounds per short ton) of aluminum produced. New sources are assumed to be of the prebaked process only. It is further assumed that the New Source Performance Standards for fluorides will be met by the same control processes applied for particulate control at no additional cost. Assumed control processes for the three production processes are shown below:

Cell type	Primary control	Secondary control
Prebaked	Primary Collection (Hoods and Ducting), Plus Fluidized-Bed Dry Scrubber	None Needed
Horizontal Soderberg	Primary Collection, Wet Electrostatic Water Treatment Precipitator, Spray Tower, or Fluidized-Bed Dry Scrubber (experimental)	Spray Screen and Water Treatment
Vertical Soderberg	Primary Collection, Wet-Electrostatic Precipitator, or Spray Tower	Spray Screen and Water Treatment

In essence, these control measures consist of either very tight hooding of the electrolytic cell (usually possible only with prebake-anode systems) with control devices (adsorption on dry alumina followed by baghouse recovery of particulate) which control both volatile fluorides and particulate. On cells where hooding of the necessary tightness cannot be achieved, the escaping emissions are collected at the roof and controlled, usually with wet control devices capable of dealing with the more dilute concentrations of fluoride and particulate. In the case of prebake-anode type plants, separate control devices are applied to the anode-bake furnace (usually a wet scrubber to collect fluorides and hydrocarbons from the hot furnace gases). Carbon grinding and milling (in the paste plant) are usually controlled with baghouses or wet scrubbers.

Costing Methodology

Table A6.5.1 shows the estimated costs for air-pollution abatement. Note that the prebaked anode process is the dominant one now, and that all new plants are assumed to employ this process. Two new production processes, the Alcoa and the Toth, which are claimed to be essentially nonpolluting, are now being investigated. If successful, costs for new sources in the future might be substantially lower than indicated.

Currently, the development is in progress of standards for control of fluorides as a designated pollutant under Section III (d) of the Clean Air Act. Costs associated with whatever SIP revisions are developed are not included in this estimate.

Table A6.5.1. Primary aluminum smelting

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .123E+09

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	315.61	0.0	160.23	291.33
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	15.33	58.81	52.11	101.69	258.45
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	15.33	374.42	52.11	261.92	549.78
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	51.36	242.03	154.09	305.59	488.92
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	18.05	18.77	46.76	116.86	300.21
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	69.42	260.80	200.85	422.44	789.14
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	77.28	364.44	231.84	463.69	772.81
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	23.91	24.86	61.94	154.78	410.23
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	101.19	389.31	293.78	618.47	1183.04
TOTAL ANNUAL COSTS	170.61	650.11	494.64	1040.91	1972.18

A6.6 Primary Copper Smelting

This chapter covers the costs of air pollution controls for primary copper smelters. The chapter is limited to the smelting stage of copper production because federal air pollution regulations primarily apply to smelters, not to copper mines or refineries.

Industry Characteristics

The production of primary copper -- from mined copper ore rather than scrap -- comprises three major process stages: mining, smelting, and refining. Several of the largest copper producers are vertically integrated into all three stages. Of the seven companies that operated smelters in 1981, six operated refineries and all seven operated mines. Most smelting and refining facilities are located near the mines, the majority being in the southwestern states of Arizona, Utah, and New Mexico.

Copper is used predominantly for electrical and electronic products (e.g., power transmission lines, conductors, machinery), building construction products (e.g., tubing and plumbing), and automobile parts (e.g., radiators, wiring, and bearings). Despite the relatively strong demand for copper in the 1970's, U.S. smelting and refining of copper fell slightly in response to lower profit margins.

There were fifteen smelters in operation in 1981. The fifteen had a total capacity of 1.5 million tons of copper output per year. When compared with a total capacity of 1.9 million tons in 1975, this represents an average annual decline in smelter capacity of four percent per year. One smelter opened in 1976, one closed in 1980, and another is planning to close in the near future.

Copper smelting and refining capacity is expected to remain relatively stable in the future. Additional demand for copper will be met by exporting mined copper ore to foreign smelters and refineries and importing the refined copper to domestic fabricators.

The primary copper industry is classified into SIC 3331. Copper smelter products are further classified into SIC 33311. The value of product shipments for SIC 33311 rose from $1.36 billion in 1972 to $2.05 billion in 1979.

Emission Sources and Pollutants

Copper ore concentrate passes through three processes at a smelter: roasting or drying, smelting, and converting. Either roasting or drying prepares the ore for more efficient subsequent processing. A smelting furnace then removes iron and other impurities from the feed to form a matte of copper, iron, and sulfur. Ladles transfer the molten matte to a converter, which produces crude blister copper product by blowing compressed air into a mixture of flux (e.g., silica, sand, or rock) and the molten matte. Residual slag is returned to the smelter for further processing.

Roasters. Roasting reduces the sulfur content, removes volatile impurities, and oxidizes some of the iron in the ore concentrate to form calcined feed. Drying lowers the moisture content to form green feed and is used instead of roasting when better concentration methods have been applied to remove free pyrite from the ore. Some smelters do not use roasters or dryers because the grade of the ore concentrate obtained from mines does not require pretreatment. Both particulate matter and sulfur dioxide emissions are generated by roasting; dust only is emitted during the drying process.

Smelters. The major types of smelting furnaces used in copper smelters are reverberatory, electric, flash, and Noranda. Both reverberatory and electric smelting are batch processes. The reverberatory furnace is the oldest and most widely used. They are found in eleven out of the fifteen smelters and were installed when the smelters were built in the early 1900's. Two smelters have electric furnaces.

Flash smelting is a continuous process in which ore concentrates and flux are continuously injected into the furnace and burned in a "flash" combustion that requires no additional fuel source. A flash furnace, which is larger and more efficient than a reverberatory furnace, was installed in the most recently constructed smelter.

A Noranda smelter is a continuous smelter that performs all three processes in a single furnace. Only one of these energy efficient smelters is operating in the United States.

Sulfur dioxide is emitted from all four types of furnaces. The waste stream from batch processes flows sporadically whereas that from continuous processes is steady and easily controllable. The reverberatory furnace and Noranda smelter also emit particulate matter.

Converters. Most U.S. copper smelters use Peirce-Smith converters. Only one smelter uses the Hoboken converter. The primary pollutant of this process is sulfur dioxide, which is emitted at a relatively high concentration in the waste gas.

Fugitive Sources. All processes generate fugitive emissions of sulfur dioxide and particulate matter. Most of these emissions result from leaks in the process equipment or in the transfer equipment that directs the gas stream to process emission control equipment.

Regulations

Primary copper smelters are subject to sulfur dioxide, particulate, and opacity standards in both NSPS and SIPs. Of the two smelters subject to NSPS, one was recently constructed and the other made major modifications. The remaining smelters are subject to SIPs.

Visibility standards requiring Best Available Retrofit Technology (BART) do not apply to most smelters, because BART applies to sources that have been in operation less than fifteen years before the 1977 amendments. Most copper smelters were in operation before 1962.

NSPS. The NSPS for primary copper smelters (40 CFR 60.160) were promulgated January 15, 1976. Sulfur dioxide standards govern roasters, smelting furnaces, and converters. Particulate matter standards govern dryers, and opacity standards govern dryers and any facility that uses a sulfuric acid plant to comply with the sulfur dioxide standard. Reverberatory smelting furnaces are exempt from the sulfur dioxide standard when processing copper ore with a high level of volatile impurities (40 CFR 60.163).

The NSPS governing sulfuric acid plants (40 CFR 60.80) does not cover sulfuric acid plants at copper smelters, which are installed for the purpose of pollution control.

SIPs. Most SIPs developed in the early 1970's established sulfur dioxide emission standards achievable with RACT, as suggested by EPA (40 CFR 51, App. B). The Arizona SIP, which applies to 57 percent of smelter capacity (eight of the fifteen smelters), is the most notable exception. It places direct responsibility on smelters for meeting the primary National Ambient Air Quality Standard (NAAQS) for sulfur dioxide in the area surrounding the smelter.

The particulate matter standards are either patterned after the process weight table in Appendix B (40 CFR 51) or expressed on a control efficiency or a gas volume basis.

Since the development of these SIPs in the early 1970's, EPA determined that the sulfur dioxide emission reductions established in the SIPs could not be obtained. The 1977 Clean Air Act amendments provided for the issuance of Primary Nonferrous Smelter Orders (NSOs), which are temporary operating permits for smelters that could not comply with the standards. The NSO is an agreement among the smelter operator, the state pollution control enforcement agency, and EPA as to the technology reasonably available to each smelter. The Act required that EPA establish a mechanism for a smelter to apply for two NSOs, the first expiring in 1983, the second in 1988. NSOs were designed to permit smelters to use temporary measures of control such as tall stacks and production curtailment (discussed below).

Control Technology

Copper smelters can employ three types of control techniques to reduce emissions levels: installation of control equipment for permanent control or use of tall stacks and/or production curtailment for temporary control (only allowed for smelters operating under NSOs). Each of these is discussed below.

Control Equipment. Copper smelters generally control sulfur dioxide and particulate matter process emissions with one primary type of control equipment for each pollutant. Fugitive emissions of both pollutants are controlled with auxiliary equipment. Often, one control device is used to treat the combined emissions of one pollutant from several sources in the smelter. The following discussion of the application of control techniques is divided into three sections: sulfur dioxide process emissions, particulate matter process emissions, and fugitive emissions.

Sulfur dioxide process emission controls include sulfuric acid plants, DMA absorbers, and flue gas desulfurization (FGD) systems. Sulfuric acid plants require gas streams that have a high concentration of sulfur dioxide and a constant flow. DMA (dimethylaniline) absorbers produce liquid SO_2 from gas streams with lower or uneven SO_2 concentrations. FGD systems are absorbers that capture SO_2 from flue gases with even lower SO_2 concentrations.

The conventional acid plant has a single contact, single absorption process. Conversion efficiencies can range from 95 to 96 percent but have been reported to be as low as 60 percent. The double contact, double absorption process is an improved acid plant design that is capable of achieving conversion efficiencies as high as 99.8 percent. This high efficiency results in significantly lower tail gas emissions than those emitted from a single contact plant. The double contact acid plant provides sufficient control to meet the NSPS for sulfur dioxide.

Acid plants can efficiently control SO_2 emissions from fluidized bed roasters, electric, flash, and Noranda furnaces, and both Peirce-Smith and Hoboken converters. SO_2 emissions from multi-hearth roasters and conventional reverberatory furnaces cannot be controlled with an acid plant, because their gas streams do not have a sufficiently high SO_2 concentration for an acid plant to operate efficiently. The high SO_2 concentration waste stream emitted at a uniform rate from flash furnaces and furnaces with oxygen enriched firing provides acid plants the necessary feed for efficient performance and SO_2 control.

DMA absorbers are often used in conjunction with acid plants. The DMA process yields a concentrated SO_2 liquid that can be sold or directed to the acid plant for more efficient recovery of the sulfur dioxide.

FGD systems can also be applied to gas streams with weak SO_2 concentrations. Such systems generally use lime or limestone to absorb the SO_2 from copper smelter flue gases. Although none are now operating in the U.S., several smelters are considering an FGD system as an SO_2 control strategy.

Twelve of the fifteen copper smelters have acid plants. Acid plants in five of these smelters are double contact design, including those installed for two smelters to comply with NSPS. Two smelters operate DMA absorption (liquid SO_2) plants in conjunction with their acid plants.

Five smelters plan furnace conversions during the 1982-1988 period. Two smelters plan to convert their reverberatory furnaces to the oxygen sprinkle process, an oxygen enrichment system. Three smelters are converting their reverberatory furnaces to INCO flash furnaces. Both types of conversion will create a more consistent furnace gas stream with higher SO_2 concentration, which can be treated with existing acid plants. One of these smelters has built a new double contact acid plant. The other smelters are upgrading their acid plants from single to double contact or installing an FGD system for improved collection of the sulfur dioxide.

Of the three smelters without acid plants, one has sufficiently low emissions that no SO_2 controls are necessary for compliance. Another smelter will either install an acid plant or an FGD system. It is assumed that the third will remain uncontrolled through the 1980's, because construction of SO_2 control equipment would force it to close.

Particulate matter process emission controls are applied to gas streams prior to sulfur dioxide treatment. The electrostatic precipitator (ESP) is the collector most widely used for emissions from all sources in the copper smelter, particularly multiple hearth roasters, rotary dryers, and reverberatory furnaces. Wet scrubbers are employed on a few fluidized bed roasters, and fabric filters are used on a few multiple-hearth roasters. Cyclone collectors, which are used to capture the larger particles, often precede ESPs. Gas streams from reverberatory furnaces and Noranda smelters pass through waste heat boilers before entering the ESP. Collected dusts, which contain a high proportion of copper, are usually recycled in the smelting furnace.

Fugitive emission controls include secondary hood systems and building evacuation systems. An efficient secondary hood system comprises a fixed hood and a type of movable hood for covering specific operations. Building evacuation systems are structures that enclose the smelter and vent the emissions to the atmosphere through a baghouse.

Three smelters installed secondary hood systems by 1981, and eight are planning to install them by 1987. Because building evacuation systems cause occupational health problems, only one smelter has installed the system.

Tall Stacks. Smelters use tall stacks to direct flue gases to a sufficiently high altitude that the sulfur dioxide is diluted when dispersed into the lower atmosphere. The resulting ambient sulfur dioxide concentration is dependent on other smelter controls, the ambient concentration prior to discharge, and weather patterns. Emissions modeling must be used to achieve effective dispersion.

Production Curtailment. Copper smelters curtail production to control emissions when ground level concentrations increase as a result of adverse weather conditions. A Supplementary Control System (SCS) or "closed loop control" is the system of curtailing production in response to concentration information provided by a set of ground level monitors in the surrounding area. Use of an SCS causes a reduction in effective capacity that is reflected in the lower total capacity figures for the industry in recent years.

Cost Methodology

Air pollution control cost estimates for the copper smelting process are presented in Table A6.6.1. These costs are based on a comprehensive study of the copper industry performed for EPA by Arthur D. Little, Inc. (ADL) (EPA 230/3-78-002-1) in 1977. The costs reported in the ADL document cover controls for air, water, and solid waste pollution. EPA estimates that the air pollution control costs constitute 97 percent of the total, and we have adjusted the costs accordingly.

ADL presented annual costs for 1970 through 1987. The historic costs for 1970 through 1977 were updated to 1981 dollars and adjusted by the 97 percent factor. These and further adjustments were made to the annual costs for the period 1978 to 1987. The controls forecast by ADL in 1977 were compared to those actually installed during 1978-1981 and those currently planned for installation during 1982-1987. ADL projected that smelters would install building evacuation systems during 1979-1986. Since these were not installed, the costs for these systems were subtracted from the 1979-1986 annual ADL costs. ADL did not include costs for reverberatory furnace conversions by five smelters, an acid plant upgrade from single to double contact by one smelter, and a new double contact acid plant by another smelter, which are currently planned for 1982-1988. Estimates of these costs, which were provided by EPA along with a projected investment schedule, were added to the total.

Table A6.6.1. Primary copper smelting

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	53.90	1926.30	161.70	342.10	387.40
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	274.52	1181.78	802.29	1671.54	2573.62
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	141.50	662.90	427.10	794.10	1070.20
TOTAL ANNUAL COSTS	416.02	1844.68	1229.39	2465.64	3643.82

Chapter A6.7 Primary Lead

This chapter presents cost estimates for sulfur dioxide and particulate omission controls for primary lead smelting operations. The chapter text has been revised substantially for this edition of the Cost of Clean Air Report. Several of the changes were made to account for closure of the Bunker Hill smelter in 1981. The projected costs for meeting the ambient lead standard were revised, but the sulfur dioxide control cost estimates have not been changed for this edition.

Industry Characteristics

Lead production in the United States involves three major steps: mining, crushing, and grinding of sulfide ores, and beneficiation to produce lead concentrates; smelting of the concentrates by pyrometallurgical methods to produce impure lead bullion; and refining the bullion to separate other metal values and impurities. This chapter presents estimates of the costs of air pollution control for primary lead smelting operations. Secondary lead smelting is discussed in Chapter A6.11.

In 1979, the domestic lead mining industry included about 25 mines in seven states. All of the larger mines and many medium-sized mines concentrate ores at the mine site. Some of the smaller mines use centralized mills. Ninety percent of lead mined in the U.S. in 1979 was produced by eight Missouri mines. Primary lead smelting and refining are also concentrated in Missouri. Smelting is now done by three companies that operate five smelters (three in Missouri) and four refineries (three in Missouri). Another smelter and refinery (Bunker Hill in Idaho) was closed in 1981.

Primary lead production in the United States was 550,000 short tons in 1981. Secondary production was 778,000 tons. Sixty-five percent of the 1.29 million tons of lead consumed in the U.S. in 1981 was used in battery components. Gasoline antiknock additives accounted for ten percent, pigments seven percent, ammunition four percent, solder three percent, and miscellaneous products, such as cable covering, castings, weights, and ballast, the remainder.

Pollutants and Sources

Methods of metallurgical operation at all of the primary lead smelters are similar; the differences stem from the type of ore handled by the Missouri smelters and by the western smelters. In the West, lead ore concentrates are cleaner and have much higher amounts of gold, silver, zinc, cadmium, copper, antimony, and arsenic present. Except for a slagfuming furnace operation in the western smelters to remove the higher amounts of zinc in the concentrates, there are no major differences in the basic smelter operations.

Emissions from lead smelters are primarily particulates (including lead) and sulfur dioxide. Most of the sulfur dioxide is generated in the sintering machine. Flue-gas particulates include the following metals: lead (as high as 30 percent) and traces of zinc, antimony, cadmium, and copper. In western smelters, significant quantities of noble metals are often also emitted; at one smelter over 1 kilogram per metric ton (30 ounces per short ton) of silver and 4.8 grams per metric ton (0.14 ounces per short ton) of gold were recovered from flue-gas particulates. Thus, there is an economic reason to recover particulates in addition to fume control. The emissions from the slag furnaces (used in the western smelters to recover zinc) also include particulates containing zinc oxide and zinc dust.

Stack and fugitive lead emission levels are discussed in Control Techniques for Lead Air Emissions, Volume II (EPA-450/2-77-012). The major sources of atmospheric lead emissions are the sintering machines, blast furnaces, and dross reverberatory furnaces. The major sources of fugitive lead emissions are sintering operations, lead ore concentrate handling and transfer, and zinc fuming furnace vents.

Regulations

NSPS promulgated in 1976 (41 FR 2331) and revised in 1977 (42 FR 37936 and 41424) regulate the level of particulate and sulfur dioxide emissions and the opacity of particulate and gaseous emissions. Particulate emissions from blast or reverberatory furnaces and from sintering machine discharges are limited to 50 milligrams per dry standard cubic meter (0.022 grams per dry standard cubic foot) and 20 percent opacity. Gaseous emissions from sintering machines, electric smelting furnaces, and converters may not contain more than 0.065 percent sulfur dioxide and may not exceed 20 percent opacity.

Several states have specific regulations for nonferrous smelters that govern primary lead smelters. Appendix B (40 CFR 50) suggests sulfur dioxide emission limits achievable with RACT for lead smelters and provides general process weight rate limitations for particulate emissions. The 1977 Clean Air Act Amendments provide for the issuance of Nonferrous Smelter Orders in cases where enforcement of the SIP limits would result in closure of the smelter.

NAAQS for lead were promulgated in 1978 (43 FR 46258). Primary lead smelters are listed among other significant point sources whose air quality impact must be specifically addressed in the SIPs (40 CFR 51.80). The ambient standard of 1.5 micrograms per cubic meter requires stringent control of both stack and fugitive emissions. Controls required to meet the ambient standard may also assist in achieving OSHA lead control standards.

Control Techniques

In 1973, two of the five U.S. smelters now in operation used sulfuric acid plants to control sulfur oxides in sintering machine off-gases. Removal of particulates from the strong sulfur dioxide gas stream (e.g., via scrubbing) is also a requirement for effective operation of the acid-plant system. In smelters without acid plants, baghouses are used to remove most of the particulates in the cooled processing off-gases, and sulfur oxides are not controlled. Baghouses are also used by smelters with acid plants to treat exhaust gases from blast and dross reverberatory furnaces and weak gas streams from sintering machines. These baghouses may be considered part of the smelter's process equipment. Their use is common industry practice due to the value of the recovered products.

Costing Methodology

The SIP costs reported in Table A6.7.1 assume the addition of single-contact sulfuric acid plants to three of the smelters, one of which was in place by 1979. The other two acid plants were assumed to be installed by 1984. The additional gas-cleaning equipment required to operate the acid plants is also included in the SIP cost estimates. Capital and operating cost functions were developed from control cost estimates provided in Volume 1 of the NSPS background document (EPA-450/2-74-002a).

The control costs in the table also include a component for compliance with the ambient lead standard. These estimates are based on the "Economic Impact Assessment for the National Ambient Air Quality Standard for Lead" (EPA, OAQPS, November 22, 1977) and an addendum (May 25, 1978). The total capital investment for additional fugitive controls for the five primary lead smelters is estimated at $12.9 million (1976 dollars). Annual O&M costs are estimated at $1.5 million. Capital expenditures were assumed to be spread evenly over the years 1985-1987.

Table A6.7.1. Primary lead

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	3.15	1.05	10.28	27.39
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	3.15	1.05	10.28	27.39
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.55	0.83	1.66	5.73	27.16
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.55	0.83	1.66	5.73	27.16
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.18	0.23	0.48	1.70	15.38
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.18	0.23	0.48	1.70	15.38
TOTAL ANNUAL COSTS	0.73	1.06	2.13	7.43	42.55

Chapter A6.8 Primary Zinc Smelting Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS for primary zinc smelters (40 CFR 60.170) was promulgated on January 15, 1976, and revised in 1977. The regulations set particulate and opacity standards for sintering machines and sulfur dioxide and opacity standards for roasters.

Appendix B (40 CFR 51, App. B.) states that 90 percent removal of sulfur oxides is achievable by RACT at existing zinc smelters. However, because it was determined that this degree of control was not achievable, Primary Nonferrous Smelter Orders were established in the 1977 Clean Air Act Amendments as a means for industry, EPA, and state air pollution control agencies to agree upon RACT on a plant-by-plant basis.

As of 1976, Pennsylvania was the only state to have regulations controlling primary zinc smelters specifically. The regulations limit sulfur oxide emissions from zinc roasting and zinc sintering operations.

Industry Characteristics

Zinc ranks after aluminum, copper, and lead in tonnage of nonferrous metals produced in the United States. Major uses are zinc-base alloys, particularly die-cast alloys used in automotive and electrical equipment (41 percent); galvanized steel used in construction and electrical transmission equipment (36 percent); brass and bronze used for plumbing, heating, and industrial equipment (14 percent); zinc chemicals, particularly zinc oxide, used in the rubber, paint, and ceramic industries (4 percent); and rolled zinc used in dry cells and lithographic plates (2 percent).

The principal ore minerals are sulfides, which may be predominantly zinc ores or lead-zinc ores. Also, some zinc is obtained from lead-base and copper-base ores. Zinc sulfide concentrates produced from these ores are converted to the oxide state (calcine) by roasting, and then reduced to metallic zinc either by electrolytic deposition or by distillation in retorts or furnaces. In plants using distillation methods, the calcine is given an additional sintering step to provide a more compact feed as well as to remove impurities. Some zinc-producing companies also produce zinc oxide. In pyrolytic plants, both zinc metal and zinc oxide are produced from zinc vapor, either condensed to zinc metal, or oxidized in a chamber.

The zinc industry has undergone great changes in the period 1968 to 1976, shrinking from 15 smelters in 1968 to seven in 1979. The old technology of horizontal retort smelting has been completely replaced, and five of the seven plants use the electrolytic process. One of the remaining pyrothermic plants is presently scheduled for closure.

The zinc industry is projected here to remain essentially the same size for the foreseeable future due to the balance of process technology, production costs, competitive materials, and foreign competition.

Pollutants and Sources

Emissions from zinc reduction plants are primarily particulates and sulfur dioxide from the roasters in the electrolytic plants, and from the roasters and traveling-grate sintering machines in the pyrothermic plants. In the electrolytic plants, the calcine from the roaster is substantially sulfur free so that there is a heavy concentration of sulfur dioxide in the off-gases. For the pyrothermic plants, roaster off-gases are also heavy in sulfur dioxide, but there are only light concentrations of sulfur dioxide in the sintering machine off-gases. Particulates are relatively heavy in both streams.

Control Technology and Costs

Sulfur oxide and particulates in roaster off-gases are now being controlled by the use of sulfuric acid plants in all of the present seven plants. Particulate control necessary for the effective operation of the acid plant system is achieved with associated gas-cleaning equipment. With the closing of the horizontal retort plants, all the roasters in the primary zinc plants are controlled with acid plants. In the two remaining pyrothermic plants, the sintering machine particulates are controlled in one plant by settling flues, electrostatic precipitators, and a baghouse, in the other, by a venturi scrubber.

Industry Cost Model

The approach to estimating the cost of compliance for this industry considered SO_x control in terms of sulfuric acid plant installations, and divided those into the following categories:

- "Old", single-pass acid plants; acid plants constructed before 1970 were not considered to be associated with the costs due to the Clean Air Act
- "New", double-pass acid plants installed since 1970

The costs estimated on the above basis are listed in Table A6.8.1.

Table A6.8.1. Primary zinc smelting industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .323E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	20.95	8.41	8.41	11.29
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	20.95	8.41	8.41	11.29
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	3.86	17.63	11.58	23.16	37.67
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	3.86	17.63	11.58	23.16	37.67
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	1.66	7.52	4.98	9.97	16.61
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.66	7.52	4.98	9.97	16.61
TOTAL ANNUAL COSTS	5.52	25.15	16.57	33.13	54.28

Chapter A6.9 Secondary Aluminum

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

No NSPS has been proposed for secondary aluminum plants. Particulate standards in SIPs apply to this industry. Most states have general process weight rate standards patterned after those suggested in Appendix B (40 CFR 51, App. B) as achievable with RACT. Only Pennsylvania specifically regulates particulate emissions from the sweating, melting, and refining of aluminum.

Industry Characteristics

In this report, the secondary aluminum industry is defined as that industry which produces secondary aluminum ingot, or hot metal, to chemical specifications from aluminum scrap and sweated pig. Therefore, the industry covered here excludes primary aluminum companies, the activities of the nonintegrated fabricators, and scrap dealers.

All metallic scrap can be divided into new and old (or obsolete) scrap. New aluminum scrap is generated in primary aluminum production, semifabricated aluminum mill products, or finished industrial and consumer products. Such scrap includes aluminum borings, turnings, clippings and punchings, forgings, dross, skimmings, and slag.

Old aluminum scrap consists of those aluminum-bearing end products that are discarded at the end of their economically useful lives and are collected for metal recovery. Old aluminum scrap therefore may be almost any aluminum item that has sufficient weight and cleanliness that is economical to recycle. Typical items are cans, utensils, automobile parts, wire and cable, and pipe. The major markets for aluminum are in building and construction, transportation, electrical equipment and supplies, containers and packaging, and machinery and equipment. Obsolete products from any of these market segments can and probably will end up as recycled scrap. It is estimated that the secondary aluminum industry will have an annual growth rate of about 6 percent between now and 1985. The basis for this estimate is the growing realization that the recycling of aluminum aids in conserving natural resources, that recycling of aluminum requires approximately 10 percent of the energy required to produce primary aluminum, and recycling helps in cleaning up the environment. Also, there is considerable interest in recycling municipal solid wastes for recovery of Btu values from paper, plastics, and rubber, recovery of ferrous and nonferrous metals, and alleviating the problems of landfill disposal.

The secondary aluminum smelter industry at the end of 1977 consisted of about 70 companies operating about 90 plants. These figures do not include those plants operated by primary aluminum producers. The plant inventory available to this study is believed to be approximately accurate with regard to the relatively large secondary aluminum smelters. However it is likely that not all small smelters were identified. The secondary metals industry, including the secondary aluminum smelters, is different from many other industries. The secondary aluminum smelter industry is made up of a rather large group of small- to medium-sized companies, and a small group of large companies. The smaller companies are not highly capitalized and their existence tends to rest on being able to purchase scrap at the proper price so that a company may process it and make a profit at the price the buyer will pay. It is not unusual for secondary smelters to suspend operations or go out of business when the price structure of buying and selling is not favorable. The level of availability of the proper scrap raw material in a smelter area also influences the size of operation.

The identifiable annual capacity of the secondary aluminum ingot industry at the end of 1977 was estimated to be 968,300 metric tons (1,065,100 short tons). It is believed that the actual capacity may be closer to 1.1 million metric tons (1.2 million short tons).

Pollutants and Sources

The most serious emission sources during secondary aluminum smelting are: the drying of oil from borings and turnings, the sweating furnace, and the reverberatory furnace. Emissions from the drying process are vaporized oils, paints, vinyls, and other hydrocarbons; the sweating furnace produces vaporized fluxes, fluorides, etc; and the reverberatory furnace emissions are similar to the other two plus hydrogen chloride, aluminum chloride, and magnesium chloride from the chlorine gas treatment used to remove magnesium. As of 1970, an estimated 25 percent of chlorination station emissions were controlled, and it is estimated that by 1980, 80 percent will be controlled.

The several processes that cause emissions during the operation of a reverberatory furnace must be understood to calculate control costs properly. These are:

- Emissions at the forewell,
- Emissions from the bath, and
- Emissions caused by chlorination.

Emissions at the Forewell. Secondary smelters charge scrap directly into the forewell of the reverberatory furnace, and any oil, paint, vinyl, grease, and other hydrocarbons, on the scrap vaporize. The emissions from the charging process vary greatly with the material charged. Quantitative data on the forewell emissions or the need for control are not available and costs or possible costs cannot be estimated.

Emissions From the Bath. During the time the aluminum bath is molten, it is covered with a flux to protect it from oxidation.

Emissions Caused by Chlorination. The magnesium content of scrap aluminum can be reduced by chlorination, but chlorination produces chloride emissions. Maximum magnesium removal requires about 18 kilograms of chlorine per metric ton (36 pounds per short ton) of aluminum which has an emission rate of 9 kilograms of particulates per metric ton (18 pounds per short ton) of aluminum. Magnesium removal is practiced by plants representing 92 percent of the estimated industry capacity. A small portion of these plants use aluminum fluoride fluxing for magnesium removal rather than chlorine. This report assumes that control costs for these few plants are similar to those that use chlorination. Wet scrubbing is the usual means of controlling chlorination station emissions; recent innovations on a dry control process are being tested.

Control Technology and Costs

Dryer emissions are often treated with afterburners; however, there are insufficient data relating to the drying operations to permit evaluations of possible costs that might be expended to meet air-quality specification.

Sweating furnace emissions, fluoride emissions from fluxes, organic materials, oils, and others, can be controlled by using afterburners, followed by a wet scrubber or baghouse. However, no data are available on the number, capacity, or location of sweating furnaces. Thus, a realistic estimate of control costs cannot be made.

The costs reported here were based on the assumption of the application of caustic scrubbers to the known chlorine demagging operations. The estimated costs developed for this industry are given in Table A6.9.1.

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

Table A6.9.1. Secondary aluminum

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	18.59	3.31	3.31	8.53
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.88	5.80	5.33	11.68	25.68
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.88	24.40	8.64	14.99	34.21
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	2.88	8.52	8.64	17.27	28.60
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.46	1.85	3.66	9.69	28.48
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	4.34	10.38	12.30	26.97	57.08
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	3.09	9.17	9.26	18.51	30.85
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.98	2.51	4.96	13.12	38.54
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	5.07	11.68	14.22	31.63	69.39
TOTAL ANNUAL COSTS	9.41	22.06	26.52	58.60	126.47

Chapter A6.10 Brass and Bronze Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS for secondary brass and bronze smelters (40 CFR 60.130) was promulgated on March 8, 1974. The standards govern particulate emissions from reverberatory furnaces and plume opacity from reverberatory, blast, and electric furnaces.

The brass and bronze industry is subject to SIP particulate standards. Most states have general particulate standards, which are patterned after Appendix B (40 CFR 51, App. B). Several states have applied the NSPS to existing brass and bronze smelting operations. Pennsylvania is the only state with a process weight regulation for particulates from the melting and refining of brass and bronze.

Industry Characteristics

The secondary brass and bronze industry may be divided into two segments: ingot manufacturers and brass mills. Both segments of the industry charge scrap into a furnace where it is melted and alloyed to meet design specifications for chemical composition. Ingot manufacturers use either a stationary reverberatory furnace or a rotary furnace for most of their production. The daily capacity range is from 4.5 to 90 metric tons (5 to 100 short tons) for reverberatory furnaces, and from 2 to 27 metric tons (2 to 30 short tons) for rotary furnaces. Small quantities of special alloys are processed in crucible or electric-induction furnaces. A few cupolas exist in which highly oxidized metal, such as skimmings and slag, is reduced by heating the charge in contact with coke. Ingot manufacturing invariably requires injection of air to refine the scrap. Brass mills use scrap that does not require such extensive refining; the channel induction furnace is the most common type used in these mills.

The number of bronze ingot manufacturing furnaces in the industry was estimated to be 122. Of these furnaces, 13 were large, 29 were medium, and 80 were small. The large furnaces produced 50 percent of the total annual ingots, while the medium furnaces produced 30 percent, and the small furnaces produced 20 percent.

No substantial growth is expected in the ingot manufacture; in 1980, ingot production is expected to be at the level of 272 thousand metric tons (300 thousand short tons). Adequate capacity currently exists in terms of additional available operating hours to be able to meet increases in demand.

The capacity of channel induction furnaces for brass mills ranges from 0.5 to 5 metric tons (0.6 to 6 short tons), with smaller furnaces being the most common. It was estimated that there were 35 plants in 1978 with an average of 3.7 furnaces per plant, or a total of 130 furnaces.

Pollutants and Sources

Metallurgical fumes, containing chiefly zinc oxide and lead oxide, are the major emissions from the reverberatory and rotary furnaces used by ingot manufacturers and from the induction furnaces used by the brass mills. Fly ash, carbon, and mechanically produced dust are often present in the exhaust gases, particularly from the furnaces used by the ingot manufacturers. Zinc oxide and lead oxide condense to form a very fine fume which is difficult to collect. The emission factors for particulates are 35 kg per metric ton (70 pounds per short ton) of metal charged for a reverberatory furnace, 30 kg per metric ton (60 pounds per short ton) for a rotary furnace, 3.2 kg per metric ton (6.4 pounds per short ton) for an electric induction furnace, 6 kg per metric ton (12 pounds per short ton) for a crucible furnace, and 36.75 kg per metric ton (73.5 pounds per short ton) for a cupola furnace.

Control Technology and Costs

Ingot manufacturers use fabric-filter baghouses, high-energy wet scrubbers, and electrostatic precipitators because of their high efficiency in collecting the fine zinc oxide fumes; 67 percent use a baghouse, 28 percent use a scrubber, and 5 percent use an electrostatic precipitator.

Assumptions were that the collected dust has a value of 10 cents per kilogram (4.5 cents per pound), and an average collector 97.5 percent efficiency. This value of collected dusts was applied as a credit to control costs.

Fabric filter baghouses are used on the brass induction furnaces to collect the particulates. Investment and annual costs were obtained from three plants that use furnaces with capacities ranging from 22 to 32 metric tons (24 to 35 short tons) per day. The average value for the three plants was used for the model furnace of 25 metric tons (27.6 short tons) per day. No credit for collected dust is assumed for brass mills.

Control costs and industry operating statistics are detailed in Table A6.10.1.

Table A6.10.1. Brass and bronze industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	18.07	0.0	0.0	7.99
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.40	1.32	1.16	2.48	5.17
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.40	19.39	1.16	2.48	13.16
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	2.38	8.20	7.13	14.26	23.55
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.33	0.43	0.82	2.14	6.06
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.70	8.63	7.95	16.40	29.61
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	1.96	4.10	5.08	10.97	18.01
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.12	0.16	0.30	0.78	2.22
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.08	4.25	5.38	11.75	20.23
TOTAL ANNUAL COSTS	4.79	12.88	13.32	28.15	49.83

Chapter A6.11 Secondary Lead Smelting

This chapter presents cost estimates for control of lead and other particulate emissions from secondary lead smelting processes. This edition incorporates revisions of the regulations and industry characteristics sections of the chapter text, in addition to minor changes in the costing methodology.

Regulations

Secondary lead smelters are regulated by NSPS promulgated on March 8, 1974 (40 CFR 60.120). The NSPS limit particulate emissions and opacity for reverberatory and blast (cupola) furnaces and opacity for pot furnaces with a capacity greater than 550 pounds.

SIPs establish particulate and lead emission limits for secondary lead smelters. State standards for particulate emissions are often provided in general industrial process weight rate or concentration limitations. RACT can meet the standards of the particulate process weight table of Appendix B (40 CFR, Part 51). Pennsylvania has a specific process weight limit for secondary lead smelting. Several states have incorporated the NSPS into their regulations and have made them applicable to existing secondary lead smelters. SIPs must also include additional requirements for control of fugitive lead emissions at secondary smelters whose emissions contribute to violations of the lead NAAQS.

Industry Characteristics

The secondary lead industry is defined as the industry that recovers lead or lead alloys by smelting lead scrap; this does not include the activities of scrap dealers who may sweat lead. Approximately 30 companies in the secondary lead smelting industry operate about 44 plants.

The amount of secondary lead produced by all sources, as reported by the Bureau of Mines, rose from 685,000 short tons in 1975 to 880,000 tons in 1979. Secondary production then decreased to 742,000 tons in 1980 and 776,000 tons in 1981. A large component in these overall figures is associated with battery manufacture.

Emission Sources and Pollutants

Emission of particulates occurs from lead-processing furnaces. Generally, about 67 percent or more of the output of the secondary lead industry is processed in blast furnaces that are used to reduce lead oxide in the form of battery plates or dross to lead. If oxide reduction is not needed, then lead scrap can be processed in reverberatory furnaces. Kettle or pot furnaces may be used to produce small batches of alloys for molding or refining lead. These lead processing furnaces represent obvious particulate emission sources, the primary emissions being lead oxide fumes.

Other particulate emission sources are the slag tap and feeding ports on the cupolas and reverberatory furnaces. Although lead is occasionally sweated in a reverberatory furnace, reclamation of secondary lead by this means represents a very small portion of the total lead production. Emissions factors from slag operations are not known.

The industry estimate of 90 percent net control in 1970 indicates that nearly all plants had emission controls of some sort. A control increase to 98 percent estimated by 1980 was based on implementation of the New Source Performance Standards.

The ambient air quality standard of 1.5 micrograms per cubic meter will require stringent fugitive emission controls. The earliest attainment date is anticipated to be 1985.

Control Technology and Costs

Either a baghouse or a wet scrubber can be utilized to achieve emission control. The baghouse is chosen for this cost analysis because it is generally less expensive; it is assumed baghouse life averages 20 years. Since the lead oxide collected in the control equipment is recycled into the smelting furnace, it has value as a by-product; therefore, the recovery of this lead oxide lowers estimated operating and maintenance costs.

The air pollution abatement costs for the secondary lead industry presented in Table A6.11.1 were based on the following key considerations:

- Costs for controlling stack emissions were based on information in EPA-450/2-77-012 (Control Techniques for Lead), December 1977, and include costs for controlling blast and reverberatory furnaces. These costs are net of the estimated value of recovered dust.

- Costs as currently projected for controlling fugitive emissions amount to $99 million dollars (in 1976 dollars) in capital costs in the mid 1980's with an associated annual cost of $22 million per year.

  These cost estimates were developed for the economic impact assessment of the lead NAAQS and are based on installation of building evacuation systems by the plants existing at the time the NAAQS was proposed. These costs are overstated to the extent that secondary smelters are able to use less expensive controls, and they do not reflect the recent closure of several secondary smelters.

Table A6.11.1. Secondary lead smelting

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .110E+09

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	5.32	1.33	94.26	139.39
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	7.87	2.82	2.82	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	13.18	4.15	97.08	139.39
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.78	1.64	2.34	23.01	136.09
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.26	1.83	3.77	7.54	12.56
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.04	3.46	6.11	30.55	148.65
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	15.21	106.44
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	15.21	106.44
TOTAL ANNUAL COSTS	2.04	3.46	6.11	45.75	255.09

Chapter A6.12 Secondary Zinc

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

There is no NSPS for secondary zinc plants. The industry is subject to SIP particulate standards, most of which apply to all process industries and are patterned after RACT standards in Appendix B (40 CFR 51, App. B). Pennsylvania's process weight rate table has specific standards for the sweating and refining operations of secondary zinc smelting.

Industry Characteristics

Zinc ranks after aluminum, copper, and lead in tonnage of nonferrous metals produced in the United States. Major uses are zinc-base alloys, particularly die-cast alloys used in automotive and electrical equipment (38 percent), galvanized steel used in construction and electrical transmission equipment (38 percent), brass and bronze used for plumbing, heating, and industrial equipment (15 percent), zinc chemicals, particularly zinc oxide, used in the rubber, paint, and ceramic industries (4 percent), and rolled zinc used in dry cells and lithographic plates (3 percent).

Secondary zinc comes from two major sources: the zinc-base alloys and the copper-base alloys. Most of the secondary zinc that is recovered comes from reconstituted copper-base alloys; slab zinc is next in importance, followed by chemical products, and zinc dust. For purposes of this report, the 11 operating plants that comprise the secondary zinc industry use sweating and/or distilling operations to produce zinc slab, dust, and oxide solely from scrap. The secondary zinc industry is not considered to include the activities of:

- Primary zinc producers that may manufacture zinc from scrap and ore
- Secondary brass and bronze plants that recover zinc in copper alloys
- Chemical manufacturers that produce zinc compounds by chemical treatment of zinc scrap
- Scrap dealers that may sweat zinc.

The Bureau of Mines' 1976 Minerals Yearbook lists eleven secondary zinc plants with a total capacity of about 44,000 metric tons of slab zinc. The same source indicated that in 1976 about 23,500 metric tons of redistilled secondary zinc was produced at secondary smelters. Zinc oxide and zinc dust were also produced by the secondary zinc plants and by the primary zinc smelters, but no definitive tonnages of these products are published for secondary smelters.

Pollutants and Sources

At least four operations generate emissions in the secondary zinc industry: materials handling, mechanical pretreatment, sweating, and distilling. This analysis considers only control costs for emissions from the sweating and distilling operations, as insufficient data are available for calculating the possible costs of controlling emissions from the other sources.

In the sweating operation, various types of zinc-containing scrap are treated in either kettle or reverberatory furnaces. The emissions vary with the feed material used and the feed material varies from time-to-time and from plant-to-plant. Emissions may vary from nearly 0 to 14 kg of particulates per metric ton (0 to 30 pounds per short ton) of zinc reclaimed. For purposes of this report, it is assumed that the maximum emission rate applies.

In the case of the various types of zinc distilling furnaces, the accepted emission rate is 23 kilograms per metric ton (46 pounds per short ton) of zinc processed. Some distillation units produce zinc oxide, and normally utilize a baghouse for collection of the product. This report assumes that these baghouses are sufficient to meet national ambient air standards. However, for the purpose of calculating control costs, it was assumed that essentially all of the estimated zinc oxide capacity could be switched to slab zinc or dust production, and emission controls would be required.

Controlled and uncontrolled emissions from secondary zinc sweating operations cannot be estimated with an acceptable degree of probable accuracy because reliable data are not available.

Control Technology

The major emission of concern is particulates, consisting mainly of zinc oxide. Baghouses have been shown to be effective in controlling both distillation and sweating-furnace emissions except when the charge contains organic materials such as oils.

Costing Methodology

A complete accounting of secondary zinc plants by type of furnaces used and the product or products produced is not available. Based on the limited information, it is assumed that the industry's 11 plants can be represented by two models: two plants, each consisting of 7,260 metric tons per year (8,000 short tons per year) sweating capacity and 10,900 metric tons per year (12,000 short tons per year) distilling capacity; and nine plants, each consisting of 4,080 metric tons per year (4,500 short tons per year) of sweating capacity and 4,990 metric tons per year (5,500 short tons per year) of distilling capacity.

In the industry cost model, costs for baghouses are applied to the sweating and distilling capacities of the respective large and small model plants. Some uncertainty exists in the factors of utilization rate of reported capacity and multiple product lines (slab, dust, and oxide); however, the estimated costs given in Table A6.12.1 are judged to represent the costs of control at recent production levels.

Table A6.12.1. Secondary zinc

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.01	0.02	0.03	0.03	0.01
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.01	0.02	0.03	0.03	0.01
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.01	0.01	0.02	0.04	0.07
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.01	0.01	0.02	0.04	0.07
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.01	0.01	0.03	0.07	0.17
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.01	0.01	0.03	0.07	0.17
TOTAL ANNUAL COSTS	0.02	0.02	0.05	0.11	0.24

Chapter A7. Mineral-Based Industries

For the purposes of this report, the Mineral-Based Industries are defined as those establishments which gather, process, and prepare materials to be used in the construction industry. Wood products are specifically excluded; these are covered in Chapter 9. The industrial sectors covered in this chapter are the:

- Cement Industry
- Structural Clay Products Industry
- Lime Industry
- Asphalt Concrete Processing
- Asphalt Roofing Manufacture

Costs for the abatement of air pollution for these industries are summarized in Table A7. These costs and other data are repeated below in the appropriate section together with the assumptions and other details specific to each industrial sector.

TABLE A 7. MINERAL-BASED INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 7. 1	CEMENT	11.72	96.92	34.74	70.75	169.15
A 7. 2	STRUCTURAL CLAY PRODUCTS	14.40	27.80	42.77	86.85	147.04
A 7. 3	LIME	2.91	95.80	8.49	17.68	90.19
A 7. 4	ASPHALT CONCR.	10.01	429.00	43.53	74.51	374.65
A 7. 5	ASPHALT ROOFING	3.12	17.22	9.20	17.49	26.80
	TOTAL INVESTMENT	42.15	666.74	138.73	267.28	807.82

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 7. 1	CEMENT	39.91	119.00	109.11	250.58	562.65
A 7. 2	STRUCTURAL CLAY PRODUCTS	27.74	16.21	66.15	184.62	488.79
A 7. 3	LIME	53.51	205.38	155.93	326.15	611.79
A 7. 4	ASPHALT CONCR.	165.91	654.14	488.70	1005.05	1785.43
A 7. 5	ASPHALT ROOFING	5.67	12.65	14.96	33.42	59.31
	TOTAL ANNUAL COSTS	292.73	1007.39	834.85	1799.83	3507.96

Chapter A7.1 Cement Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS for portland cement plants (40 CFR 60.60) was promulgated on December 23, 1971. The regulation sets particulate and opacity limits for cement kilns and clinker coolers, and opacity limits for several other affected facilities in portland cement plants.

The cement industry is also subject to SIP particulate standards. Most states have general process weight standards patterned after Appendix B (40 CFR 51, App. B).

Industry Characteristics

Portland cement, which accounts for approximately 96 percent of cement production in the United States, is processed from a blend of various calcareous, argillaceous, and siliceous materials including limestone, shell chalk, clay, and shale. As the binder in concrete, portland cement is the most widely used construction material in the United States. The four major steps in producing portland cement are: quarrying and crushing; blending, grinding, and drying; heating the materials in a rotary kiln to liberate carbon dioxide and cause incipient fusion; and fine-grinding the resultant clinker, with the addition of 4 to 6 percent gypsum. Finished cement is shipped either in bulk or in bags. All portland cement is produced by either wet or dry grinding processes, the distinguishing characteristic being whether the raw materials are introduced into the kiln as a wet slurry or as a dry mixture.

In 1971, 170 plants producing portland cement clinker, plus five plants operating grinding mills to produce finished cement, were controlled by 51 companies and were located in 41 states and Puerto Rico. These plants had an annual capacity of 79.5 million metric tons (87.7 million tons).

By 1977 (year end), some 160 plants were in operation with an annual capacity of 87.5 million metric tons (96.4 million short tons). Fifty percent of this cement industry capacity is owned by multiplant companies, and the eight leading companies account for about 47 percent of the total. Overcapacity has resulted in low profit margins and has inhibited modernization and construction of new plants. More stringent air-pollution regulations have increased both capital and operating costs. Recent trends are toward an increase in utilization. Typical utilization is about 80 percent. Recent trends are toward increased operations through installation of larger kilns to replace older marginal kilns, permitting more economic and efficient pollution control. The cement manufacturing plant capacity and size distribution are given in Table A7.1.1.

Table A7.1.1. Cement Manufacturing Plant Size Distribution (capacities in metric tons with short tons in parentheses)

Annual capacity range (1000)	No. plants	Total annual capacity 1000	Total capacity (%)
Less than 181 (less than 200)	4	603 (665)	0.7
181-363.1 (200-400)	43	12,061 (13,298)	13.8
363-544 (400-600)	47	21,303 (23,487)	24.3
544-726 (600-800)	38	24,037 (26,502)	27.5
726-907 (800-1000)	8	6,483 (7,148)	7.4
Greater than 907 (1000)	20	23,030 (25,392)	26.3
Totals	160	87,521 (96,495)	100.0

Size distribution is expected to shift upwards as new plants are constructed and existing plants modified or closed, so the total number of plants is expected to remain about the same. It is also assumed that there will be no major shift in production capacity percentages between dry and wet grinding processes, with the latter presently estimated at 56 percent.

Pollutants and Sources

Primary emission sources are the dry-process blending and grinding, kiln operation, clinker cooler, and finish grinding. Other sources include the feed and materials-handling systems. The primary air pollutant is dust particulates. The estimated dust-emission factor for an uncontrolled dry-process kiln is 122 kg per metric ton (244 pounds per short ton) of cement, compared with 114 kg per metric ton (228 pounds per short ton) for the wet-process plant, giving a weighted average emission factor of 118 kg per metric ton (236 pounds per short ton) of product. The corresponding emission factors for the blending, grinding, and drying processes are 48 kg (dry) and 16 kg (wet) per metric ton (96 and 32 pounds per short ton), respectively, for a weighted average of 32 kg per metric ton (64 pounds per short ton).

Control Technology

Emissions from the blending, grinding, and drying process are generally controlled with fabric filters. Where ambient gas temperatures are encountered during grinding, conveying, and packaging processes, fabric filters are used almost exclusively. The greatest problems are encountered with high-temperature gas streams which contain appreciable moisture.

Both fabric filters and electrostatic precipitators are used in controlling dust emissions from the kilns. Condensation problems from the high-moisture content in the wet-process plant may be overcome by insulating the ductwork and preheating the systems on start-up. Current state regulations may be met either with fabric filters or with electrostatic precipitators; however, fabric filters may be required to meet emissions limits established by the NSPS. At least one plant has a wet scrubber, but costs for the plant were estimated on the basis of an electrostatic precipitator.

Costing Methodology

The total cost of control for portland cement plants was found by estimating the costs for control devices for grinding, mixing and drying (drying not included in the wet process) and/or kilns, which are the major sources of pollutants. Baghouses are used for dry-process kilns and electrostatic precipitators for wet-process kilns. Baghouses were assumed to have been used for the combined grinding, mixing, and drying processes. Other sources, including clinker coolers, packaging, and crushing, are not costed due to prevailing industry control prior to the 1970 Clean Air Act and/or minimal costs.

The capital cost of baghouses is assumed to be proportional to the 0.91 power of capacity, while the capital cost of electrostatic precipitators is proportional to the 0.67 power of capacity; in each case, the operating cost is linearly proportional to the capacity. The cost of baghouses for the grinding, mixing, and drying operations was scaled in the same manner. However, the required size was scaled by 0.78 (dry) and 0.26 (wet) to account for the smaller airflow rates of these processes, and the absence of control required for the wet-process raw material grinding mills.

Control costs for the cement industry are detailed in Table A7.1.2. It should be noted that only costs for new sources are indicated; reportedly all existing plants are in compliance with State Implementation Plans. (EPA report FR-41U-649, August, 1972).

Table A7.1.2. Cement industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	11.72	79.85	34.74	70.75	160.29
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	11.72	79.85	34.74	70.75	160.29
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	15.07	42.87	40.59	95.22	219.86
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	15.07	42.87	40.59	95.22	219.86
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	19.67	55.98	53.00	124.32	291.30
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	19.67	55.98	53.00	124.32	291.30
TOTAL ANNUAL COSTS	34.74	98.85	93.59	219.54	511.16

Chapter A7.2 Structural Clay Products Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

No NSPS covers the structural clay products industry. SIPs regulate sulfur dioxide, hydrocarbon, and carbon monoxide emissions from facilities in this industry. The SIP limits, which are often patterned after RACT standards in Appendix B (40 CFR 51, App. B), apply to general process industries and are expressed as concentrations, gas volumes, or process weight rates.

Industry Characteristics

In 1978, 466 plants in the United States manufactured structural clay products, including common brick, fireclay or refractory brick, and sewer pipe. The brick category represents approximately 90 percent of the total production of structural clay materials, with common brick being by far the largest category, representing approximately 75 percent of total production. Plants are located in 45 states with North Carolina, South Carolina, Ohio, Pennsylvania, and Texas accounting for about 45 percent of production capacity.

For purposes of estimating air abatement costs, the industry was divided into those plants using either continuous tunnel kilns or batch kilns; an average plant capacity was selected for each process, as shown in Table A7.2.1.

Miscellaneous clays and shales are used to manufacture common brick, sewer pipe, and refractory brick. Typically, the plants are located in the proximity of the clay mines. The clays are crushed and ground at the plant, after which they are screened and mixed with water for the forming operation. Common brick, sewer pipe, and some refractory brick are formed by extrusion; most refractory brick are formed by die pressing.

The formed materials are fire-treated by either continuous tunnel or intermittent periodic kiln processes. In the continuous tunnel kiln, the charge is preheated by airflow escaping from the bake oven, passed through the oven at temperatures of approximately 1,050 C (1,900 F), then passed through a cooling stage. In contrast, the periodic kiln heats the charge from ambient temperature to a peak temperature, after which the fuel is shut off, allowing the charge to cool to ambient temperature again; this cycle requires about 2 weeks, during which fuel is burned about 50 percent of the time. The remainder of the period is used for cooling and physical discharging of the product, steps which emit few, if any, air pollutants.

Table A7.2.1 Plant distribution assumed for structural clay industry (capacity in thousands of metric tons per year with thousands of short tons per year in parentheses)

	Average capacity	No. plants	Estimated 1974 capacity (thousands)	Total capacity (%)
Periodic kilns	21 (23)	336	6.9 (7.6)	35
Continuous Tunnel kilns	100 (110)	130	12.9 (14.2)	65
Total		466	19.8 (21.8)	100

A process frequently practiced by manufacturers of common brick is flashing. This process involves firing the brick in a reducing atmosphere to achieve architecturally desirable surface colorations. The process is noted because when it is used in conjunction with periodic kilns, carbon monoxide and/or hydrocarbon emissions usually result.

Pollutants and Sources

Atmospheric emissions from the manufacture of clay construction products are primarily sulfur dioxides released during the firing process. These originate from the sulfur contained in the clay and in the fossil fuels consumed in the firing operation. Uncontrolled sulfur dioxide emissions are estimated to be about 3.7 kg per metric ton (7.4 pounds per short ton) of clay processed. The flashing process associated with the manufacture of certain types of brick can also result in hydrocarbon and carbon monoxide emissions. Approximately 4.2 kg of hydrocarbons and/or carbon monoxide are estimated to be released per metric ton (8.4 pounds per short ton) of brick flashed.

Control Technology and Costs

It is anticipated that wet scrubbers will be used to control sulfur dioxide emissions from the production of clay construction materials. Only a few plants were found to be exercising this or any other control option. Hydrocarbon and carbon monoxide emissions can be controlled by using afterburners. The requirement for afterburners will depend on the duration of the flashing treatment at different plants. Likewise, it is probable that certain plants will have minimal requirement for scrubbers because of the negligible sulfur content of some clays. About 10 percent of existing plants producing common brick, sewer pipe, and refractory brick were assumed to be either equipped with adequate controls or using new clay materials sufficiently low in sulfur content to avoid the need for wet scrubbers.

Costs and industry operating statistics are detailed in Table A7.2.2.

Table A7.2.2. Structural clay products industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	14.40	27.80	42.77	86.85	147.04
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	14.40	27.80	42.77	86.85	147.04
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	11.49	6.78	27.45	76.21	200.17
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	11.49	6.78	27.45	76.21	200.17
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	16.26	9.43	38.70	108.42	288.61
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	16.26	9.43	38.70	108.42	288.61
TOTAL ANNUAL COSTS	27.74	16.21	66.15	184.62	488.79

Chapter A7.3 Lime Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of applicable regulations.

Regulations

The NSPS for lime manufacturing plants (40 CFR 60.340) was promulgated on March 7, 1978. The regulation set particulate and opacity limits for rotary lime kilns and particulate limits for lime hydrators. Following a review of this NSPS, EPA proposed a revision on September 2, 1982, that would relax the particulate limit and exempt lime hydrators from the standard (47 FR 38831).

States set general particulate emission standards, which apply to lime plants. Most SIPs are patterned after the general process weight table in Appendix B (40 CFR, 51 App. B). Only a few states (e.g., Pennsylvania and Iowa) have regulations with specific limits on lime manufacturing emissions.

Industry Characteristics

As of 1977, there were 162 lime-producing plants in the United States. These plants can be divided into seven size ranges, based upon production; the number of plants in each size range and their estimated production are shown in Table 7.3.1.

The U.S. lime industry can be conventionally divided into two product sectors. Approximately 22 percent of the output is consumed by the producers, while the remaining 78 percent is sold in the open market. Plants are located in 41 states and Puerto Rico. Over 22 percent of U.S. capacity is in Ohio, and other major capacities are located in Pennsylvania, Texas, and Michigan. Recent trends are toward the closing of small, old plants and replacing old kilns with larger units.

In 1977, producers at 162 plants sold or used 18.1 million metric tons (19.9 million short tons), according to the Bureau of Mines, U.S. Department of Interior. This was a 1 percent decrease from 1976, and 8 percent below the 1974 record.

Should the use of lime in processes for the removal of sulfur oxides from combustion gases become standard practice, the demand for lime will be increased substantially. The number of plants, meanwhile, has declined from 195 in 1970 to 162 in 1977. Further consolidation may be expected to economically justify the increased cost of emissions controls.

Table A7.3.1. Lime Industry Production Distributions in 1977 in Thousands of Metric Tons Per Year (with thousands of short tons per year in parentheses)

Size range	No. plants	Estimated 1977 production (1,000)	Percent of total
0-9 (0-10)	22	112 (124)	1
9-23 (10-25)	27	419 (462)	2
23-45 (23-50)	32	1,050 (1,158)	6
45-91 (50-100)	21	1,429 (1,575)	8
91-181 (100-200)	24	3,310 (3,649)	18
181-363 (200-400)	28	6,390 (7,640)	38
More than 363 (More than 400)	8	4,879 (5,378)	27
Total	162	18,128	100

Source: Mineral Industry Surveys, Bureau of Mines, 1977.

Lime is formed by expelling carbon dioxide from limestone or dolomitic limestone by high temperatures. This calcination process forms quicklime. Hydrated lime is made by the addition of water to the quicklime. The calcination of dolomite results in dead-burned (refractory) dolomite.

Major uses of lime are for basic oxygen steel furnaces, alkalies, water purification, other chemical processes, and refractory dolomite.

About 70 percent of lime is produced in two basic types of rotary kilns: the long rotary kiln, and the short rotary kiln with external preheater. Vertical kilns are used to supply 28 percent of lime. Almost all new lime production is done using the rotary process.

Pollutants and Sources

Atmospheric emissions from lime manufacture are primarily particulates released when crushing the limestone to kiln size, calcinating the limestone in a rotary or vertical kiln and crushing the lime to size; also, fly ash is released if coal is used in calcination. Other emissions, such as sulfur oxides, may be generated by fuel combustion.

Uncontrolled emissions from rotary kilns are about 170 kg per metric ton (340 pounds per short ton) of lime processed, compared with 4 kg per metric ton (8 pounds per short ton) from vertical kilns. However, economics favor use of the rotary kiln, and virtually all new and expanded production is expected to use this method.

Control Technology and Costs

Gases leaving a rotary kiln are usually passed through a dust-settling chamber where the coarser material settles out. In many installations, a first-stage, primary dry cyclone collector is used. The removal efficiency at this stage can vary from 25 to 85 percent by weight of the dust being discharged from the kiln.

The selection of a second stage to meet a high efficiency level of 23 mg per actual cubic meter (0.01 grain per actual cubic foot) may be either a high-energy wet scrubber, fabric filter, or electrostatic precipitator. The higher capital cost of the electrostatic precipitator may be more than offset for specific installations by lower operating and maintenance costs.

It is believed that vertical kilns can be effectively controlled to allowable emission limits with baghouses, scrubbers, or cyclone/scrubber combinations. In the latter cases, efficiencies of 99 percent have been reported.

Industry Cost Model

The industry cost model was based on production levels and plant populations from Bureau of Mines data. Eighty percent of the total U.S.

production was considered to be commercial, independent operations based on a recent EPA estimate (NSPS Support Document). The costs for the twenty percent of production by captive plants are covered by other chapters (Iron & Steel, Paper). Vertical kiln capacity has been constant since 1969 (zero growth). Baghouses were considered the predominant methods of control (60 percent) with some wet scrubbers and ESPs being used (20 percent each). The resulting estimated costs are listed in Table A7.3.2.

Table A7.3.2. Lime Industry

AIR POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) (CAPITAL IN PLACE (NEW))	.8750E+07 1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	88.22	0.0	0.0	57.23
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	2.91	2.68	8.49	17.68	32.85
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.91	90.90	8.49	17.68	90.08
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	11.60	52.10	26.80	69.59	115.85
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	1.47	0.35	3.27	10.07	33.67
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	13.07	52.45	30.07	79.66	149.52
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	33.56	149.44	100.67	201.35	335.59
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	6.47	1.07	9.96	30.67	102.54
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	40.03	150.52	110.63	232.02	438.12
TOTAL ANNUAL COSTS	53.10	202.97	140.70	311.69	587.64

Chapter A7.4 Asphalt Concrete Processing

Revision of this chapter was limited to adjusting the pollution control costs for 1981 dollars and rewriting the discussion of applicable regulations.

Regulations

The NSPS for asphalt concrete plants (40 CFR 60.90) was promulgated on March 8, 1974. The regulation sets particulate and opacity limits for dryers; screening and weighing systems, storage, transfer, and loading systems; and dust handling equipment.

General particulate limits in SIPs apply to this industry. Most states pattern these regulations on the suggested RACT standards in Appendix B (40 CFR 51, App. B).

The asbestos NESHAP (40 CFR 61.20), which was promulgated April 6, 1973, prohibits visible emissions of asbestos from the manufacture of asphalt concrete. Compliance with SIPs or NSPS virtually assures compliance with this NESHAP.

Industry Characteristics

Asphalt concrete comprises a mixture of aggregates and an asphalt cement binder. Aggregates usually consist of different combinations of crushed stone, crushed slag, sand, and gravel. Asphalt concrete plant processing equipment includes raw-material apportioning equipment, raw material conveyors, a rotary dryer, hot-aggregate elevators, mixing equipment, asphalt-binder storage, heating and transfer equipment, and mineral-filler storage and transfer equipment.

About 4,400 asphalt concrete plans in the United States directly employ about 15,400 people. In 1975, production was estimated to be 265 million metric tons (292 million short tons). Based on a 1974 survey conducted by the National Asphalt Pavement Association (NAPA) covering 960 plants, 78 percent were stationary plants and 22 percent were portable. Continuous mixers comprised 27 percent of the portable plants, compared with only 4 percent for stationary plants.

Estimation of the size distribution of plants is difficult because of a lack of data. Of the plants surveyed by NAPA, 12 percent were less than 98 metric tons per hour (108 short tons per hour) capacity at average moisture condition. About 60 percent were between 99 and 198 metric tons per hour (109 and 218 short tons per hour) and 28 percent were larger than 198 metric tons per hour (218 short tons per hour). The average size was 160 metric tons per hour (176 short tons per hour). The balance of the industry, 80 percent of the plants, has only 75 percent of the capacity. By difference, the average for these plants is 94 metric tons per hour (104 short tons per hour). The overall industry average is 110 metric tons per hour (121 short tons per hour).

Plants operate an average of only 666 hours per year because of the seasonal and intermittent nature of the work. Asphalt concrete production is essentially a batch-type operation; continuous mix represents, at most, 10 percent of the industry.

Pollutants and Sources

The predominant emissions are dust particulates from the aggregates used in making asphalt concrete. The largest sources of particulate emissions are the rotary dryer and screening, weighing, and mixing equipment. Additional sources that may be significant particulate emitters, if they are not properly controlled, are: the mineral-filler loading, transfer, and storage equipment; and the loading, transfer, and storage equipment; and the loading, transfer, and storage equipment that handles the dust collected by the emission-control system. Generally, the uncontrolled emissions from asphalt batching plants amount to 22.5 kg of dust per metric ton (45 pounds per short ton) of product.

Control Technology

Practically all plants use primary dust collection equipment, such as cyclones or settling chambers. These chambers are often used as classifiers with the collected aggregate being returned to the hot-aggregate elevator to combine with the dryer aggregate load.

The gases from the primary collector must be further cleaned before venting to the atmosphere. To meet SIP requirements, 98.3 percent abatement is sufficient. This can be achieved by the use of multiple centrifugal scrubbers. NSPS issued in 1975 allow no more than 90 mg/dscm (0.04 grain per cubic foot) of particulates or any opacity greater than 20 percent. In effect this requires the use of a high energy scrubber or a fabric filter (baghouse). The most common secondary collector used to meet NSPS is expected to be the baghouse, although venturi scrubbers are used in some plants. The baghouse allows dry collection of dust which can be returned to the process or disposed of in a landfill. The venturi scrubber makes dust hauling expensive due to the wetting of the dust. Also, the use of large settling ponds and the possible need for water treatment discourage the use of venturi scrubbers.

Costing Methodology

The industry cost model developed from data discussed above covers about 440 plants (in 1974) with growth rates in the range from 6.0 to 1.3 percent in the future. Sixty percent of the industry was estimated to use baghouse and 40 percent to use wet scrubbers. The estimated costs of compliance, based on this model, are given in Table A7.4.1.

Table A7.4.1. Asphalt concrete processing

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	328.20	0.0	0.0	260.55
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	10.01	85.93	43.53	74.51	114.10
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	10.01	414.13	43.53	74.51	374.65
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	43.15	198.66	129.45	258.90	428.88
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	17.02	27.69	47.14	106.30	228.44
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	60.17	226.35	176.58	365.20	657.32
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	81.69	376.45	245.06	490.12	817.38
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	22.09	35.95	61.19	138.00	297.05
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	103.78	412.40	306.25	628.12	1114.42
TOTAL ANNUAL COSTS	163.95	638.75	482.84	993.32	1771.74

A7.5. Asphalt Roofing Manufacture

This chapter describes the cost to the asphalt roofing industry of complying with air pollution control regulations. Revisions of the chapter includes an update of industry data, redevelopment of SIP costs, development of costs for the NSPS that was proposed in late 1980, and estimation of credits due to produce recovery.

Industry Characteristics

The asphalt roofing industry produces asphalt roofing and siding products (shingles and rolls) and saturated felts. The primary raw materials are asphalt, dry felts and minerals.

In 1977, there were 110 plants producing 9.5 million tons of asphalt roofing and siding per year. Roofing accounted for 90 percent of production; siding accounted for the remainder. The distribution of production by region is fairly uniform--one-third each in the North Central and Southern regions, and the remainder about equally divided between the Northeast and the West. The value of product shipments of this industry, which is classified into SIC 29523 (Prepared Asphalt and Tar Roofing and Siding Products) totalled $1.9 billion in 1977.

Between 1972 and 1977, the number of plants increased from 102 to 110, but production remained relatively stable. Demand for roofing and siding has been stable because it is dependent on both the demand for new construction and the demand for building renovation. When new construction demand falls, renovation and remodeling demand generally rises so that the demand for roofing and siding is noncyclical.

Asphalt is a residual of oil refining. Fifteen percent of asphalt production is used to manufacture asphalt roofing and 80 percent, asphalt paving. About one-third of firms that own asphalt roofing plants also produce asphalt.

Since the primary raw material is an oil derivative, the price of asphalt roofing is a function of the price of oil. Increases in the price of oil, which subsequently produce increases in the price of asphalt roofing, have depressed the demand for asphalt roofing. No growth is expected for the industry during the next several years.

Pollutants and Sources

The production of asphalt roofing shingles and felts involves saturating fiber media with asphalt. Raw asphalt (asphalt flux) is first prepared by an air "blowing" or dehydrogeneration process in a blowing still. Asphalt roofing plants either operate their own blowing stills or purchase prepared asphalt. The products of the blowing operation are asphalt saturant and coating asphalt. Asphalt saturating machines saturate felts with hot asphalt saturant by either spraying or dipping or by a combination of spraying followed by dipping. The saturated felt passes to a wet looper where saturant asphalt continues to saturate the felt. For surfaced products, a coater coats felts with a mixture of coating asphalt and mineral stabilizers, called fillers (e.g., lime, silica, and slate). Mineral surfacing materials, either parting agents (talc or sand) or granules, are applied to surfaced products for protection.

Inorganic and organic particulate matter and gaseous hydrocarbons are the primary pollutants from asphalt roofing plants. There are also small amounts of carbon monoxide, sulfur dioxide, and aldehydes. The major source of gaseous hydrocarbon emissions is the asphalt blowing still. The sources of particulate emissions are asphalt blowing stills (for plants that operate them), saturators, wet loopers, coaters, asphalt storage tanks, and mineral storage bins.

Regulations

SIPs. Most states in which asphalt roofing plants are located have particulate standards for all types of process emission sources. These regulations are similar to RACT process rate tables (40 CFR 51, App. B). Volatile organic compound (VOC) standards are patterned after suggested RACT standards in Appendix B or Los Angeles Rule 66 for organic compound emissions from organic solvents. By 1977, only twenty states had included VOC standards in their SIPs. The 1977 Clean Air Act Amendments require that the remaining states with ozone nonattainment areas revise their SIPs to include VOC regulations.

NSPS. The NSPS for asphalt processing and asphalt roofing manufacture was proposed November 18, 1980 (45FR76404). It includes particulate emission standards for blowing stills and saturators and opacity standards for blowing stills, saturators, asphalt storage tanks, and mineral handling and storage areas. The particulate limits for blowing stills vary according to the type of blowing process, either conventional or catalytic, and the type of fuel oil fired in the afterburner.

Control Technology

Control systems applied to asphalt roofing plants include various types of hoods, enclosure capture systems, and add-on control devices. The most commonly used control devices are afterburners, high velocity air filters (HVAFs), electrostatic precipitators (ESPs), cyclones, and fabric filters.

Afterburners incinerate both particulate and gaseous VOC emissions from blowing stills, saturators, coaters, and asphalt storage facilities for compliance with both SIPs and NSPSs. HVAFs and ESPs can control particulate emissions from saturators and coaters to meet SIP and NSPS requirements. Control of inorganic particulate matter from filler surge and parting agent bins is achievable with cyclones for SIP compliance and fabric filters for NSPS compliance. The afterburners recover heat, which may be used for many plant processes, and the collection devices recover both hydrocarbons and minerals, which are in the form of filler and parting agent.

Compliance with SIPs requires about 80 percent removal efficiency for controls on blowing stills, filler surge bins, and parting agent bins and more than 90 percent efficiency for controls on saturators and coaters. NSPS compliance requires from 93 to over 98 percent removal efficiency for controls on all emission sources.

Existing asphalt plants are assumed to comply with SIPs by 1982 as more states establish hydrocarbon regulations in their SIPs. New and modified plants beginning operation in 1982 are assumed to comply with the NSPS upon completion.

Costing Methodology

Table 7.5.1 reports the control devices and removal efficiency assumed for costing the compliance of each emission source with SIPs and NSPS. The SIP controls include a HVAF with hood, fan, and duct on the saturator, wet looper, and coater; cyclones on the filler and parting agent bins; and an afterburner on the blowing still. The NSPS costs assume a HVAF with full enclosure hood, fan, and water spray cooler on the saturator, wet looper, and coater and on the asphalt storage tanks; baghouses on the filler and parting agent bins; and an afterburner on the blowing still. The removal efficiency levels are assumed to be sufficient for meeting each regulation, as described in the previous section. The largest one-third of the plants are assumed to operate their own blowing still.

Total costs for controls on asphalt roofing plants are presented in Table A7.5.2. Capital and O&M cost equations were developed from data on costs for SIP and NSPS controls for three model plant sizes as reported in the Environmental Impact Statement background document for the proposed NSPS (EPA 450/3-80-021a). Separate credit equations were also developed from this document to accoynt for the value of products recovered with the pollution control devices. Both costs and credits are expressed as a function of total annual production in thousands of tons.

Table 7.5.1. Control devices costed for asphalt roofing operations

Emission Source	Controls and Control Device Efficiency	
	SIP	NSPS
Saturator, wet looper, and coater	HVAF*, 93.3%, with hood, fan and duct	HVAF*, 93.3%, with full enclosure hood, ducts, fan, and water spray cooler
Filler surge bin and storage	Cyclone, 80%	Baghouse, 98.4%, with duct and fan
Parting agent bin and storage	Cyclone, 80%	Baghouse, 98.4%, with duct and fan
Asphalt storage	-	HVAF*, 93.3%, with full enclosure hood, ducts, fan, and water spray cooler
Blowing still	Afterburner with heat recovery, 77.7%, with duct and fan	Afterburner with heat recovery, 93.9%, with duct and fan

*HVAF - high velocity air filter.

Table A7.5.2. Asphalt roofing manufacture

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (EIP): .5798+07

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
EIP	3.12	17.22	9.20	17.49	26.80
REVISED EIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	3.12	17.22	9.20	17.49	26.80
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
EIP	4.30	9.69	11.39	25.70	45.94
REVISED EIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	4.30	9.69	11.39	25.70	45.94
ANNUAL O & M COSTS					
EXISTING PLANTS					
EIP	1.37	2.96	3.58	7.72	13.37
REVISED EIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.37	2.96	3.58	7.72	13.37
TOTAL ANNUAL COSTS	5.67	12.65	14.96	33.42	59.31

Chapter A8. Manufacturing and Services Industries

The subject group of industries include the following categories:

- Paint Manufacturing Industry
- Surface Coatings
- Dry Cleaning Industry
- Printing Ink Manufacture
- Synthetic Fiber (Nylon) Manufacture
- Lead-Acid Storage Batteries

These types of activities have in common the characteristics of (1) not being based on primary raw materials, their starting materials being manufactured items and (2) generating similar types of emissions, i.e., solvents and other hydrocarbons.

Costs for the control of air pollution in these industries are given in summary form in Table A8. The specific aspects and costs of air pollution control for the individual industry segments are given in more detail in the following sections.

TABLE A 8. MANUFACTURING & SERVICES
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
B.B. 1	PAINT MFG.	3.39	6.83	10.20	20.31	31.98
B.B. 2	SURFACE COATING	120.23	167.78	350.97	739.22	1005.24
B.B. 3	DRY CLEANING	0.0	0.0	0.0	142.79	407.98
B.B. 4	PRINTING INK MFG.	2.85	24.23	9.80	20.87	47.15
B.B. 5	SYNTHETIC FIBER MFG.	0.12	2.56	0.44	1.29	3.86
B.B. 6	LEAD ACID BATTERIES	0.0	21.35	0.0	0.02	15.92
	TOTAL INVESTMENT	126.59	222.76	371.41	924.51	1512.13

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
B.B. 1	PAINT MFG.	4.77	2.88	11.46	31.38	79.30
B.B. 2	SURFACE COATING	115.69	59.20	265.99	776.24	2209.04
B.B. 3	DRY CLEANING	0.0	0.0	0.0	40.22	466.61
B.B. 4	PRINTING INK MFG.	20.10	51.15	56.63	125.77	255.44
B.B. 5	SYNTHETIC FIBER MFG.	1.82	5.78	5.26	11.15	21.63
B.B. 6	LEAD ACID BATTERIES	6.29	25.28	18.86	37.73	63.83
	TOTAL ANNUAL COSTS	149.66	144.28	358.20	1022.49	3095.85

Chapter A8.1 Paint Manufacturing Industry

Revision of this chapter included adjusting pollution control costs to 1981 dollars, updating industry data, and editing the discussion of regulations, industry characteristics, and emission sources and pollutants.

Regulations

No NSPS have been developed for paint manufacturing nor are any scheduled. SIPs regulate both VOC and particulate emissions from this industry.

An increasing number of states are adopting general VOC regulations for industries, such as paint manufacturing, for which no CTG is available. These regulations are generally patterned after Los Angeles' Rule 66 or Appendix B (40 CFR 51, App. B). Both of these regulations have pounds-per-day and pounds-per-hour limits, but compliance is achieved if 85 percent control is demonstrated. Appendix B suggests the use of incineration or carbon adsorption to achieve this level of emission reduction.

Most states also pattern their general particulate standards after the suggested RACT process weight tables in Appendix B.

The asbestos NESHAP (40 CFR 61.20), promulgated April 6, 1973, prohibits visible emissions of asbestos from the manufacture of paints and coatings. Compliance with the asbestos NESHAP is achievable with particulate controls.

Industry Characteristics

In 1977, 1300 companies operated 1600 paint manufacturing plants, approximately the same number as were operated in 1972. Production of paint increased at an annual rate of 1.2 percent from 927 million gallons in 1972 to 1,040 million gallons in 1981. Production is expected to rise by only 0.1 percent annually in the 1980's.

Of 1,700 plants operated in 1976, only 653 had more than 20 employees. Based on 1972 figures, the largest 33 percent of plants account for 89 percent of paint production. It is these larger plants whose control costs are included in this chapter. The emissions levels of the smaller plants are low enough that they are exempt from regulations.

The VOC emission rate is substantially lower in the production of water-based than for solvent-based paints. Control costs in this chapter are given only for the solvent-based paint manufacturing process. Of total paint production, about 78 percent is organic solvent-based, and the remainder is water-based. This proportion is expected to remain relatively constant through the 1980's.

Paint manufacturing is classified into SIC 2851 (Paints, varnishes, lacquers, enamels, and allied products). The value of shipments for the entire SIC was $6.6 billion in 1977.

Pollutants and Sources

Paint manufacturing involves mixing or dispersing pigments in oil, resin, resin solution, or latex at room temperature. Mixing is then followed by the addition of specified proportions of organic solvents or water to obtain the desired viscosity.

Air pollutants from paint manufacturing are VOCs originating from organic solvents and particulates from paint pigments. About 1.8 pounds of particulates are emitted per short ton of pigment dispersed while the emissions of hydrocarbons are 30 pounds per short ton of pigment.

Control Technology and Costs

Reduction of hydrocarbon emissions from paint production by 85 percent, which will meet all SIPs, may be accomplished by flame combustion, thermal combustion, catalytic combustion, or adsorption. Thermal combustion (with heat exchange) is considered the most feasible method of control; equipment incorporating heat-exchange devices was chosen because of currently anticipated future fuel shortages and assumed removal efficiencies of 95 percent. Catalytic combustion units, while highly promising from the standpoint of lower fuel requirements (but higher initial investment costs), still present technical operating problems. Baghouses (fabric filters) are suitable for control of particulates emissions from pigments; particulate removal efficiencies of more than 95 percent are readily achieved.

Estimates for air-pollution control for the total industry were based on assumed compliance by plants averaging about 7.95 million liters (2.1 million gallons) of paint production per year; about 520 plants of this capacity were assumed to be in operation. Future cost predictions are complicated by the emergence of technological trends away from the use of solvent-based paints. Control costs are aggregated in Table A8.1.1.

Table A8.1.1. Paint manufacturing industry

AIR POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP): .0	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	3.39	6.83	10.20	20.31	31.98
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	3.39	6.83	10.20	20.31	31.98
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	2.77	1.67	6.66	18.27	46.13
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.77	1.67	6.66	18.27	46.13
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	2.00	1.21	4.80	13.11	33.17
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.00	1.21	4.80	13.11	33.17
TOTAL ANNUAL COSTS	4.77	2.88	11.46	31.38	79.30

Chapter A8.2 Surface Coating

This chapter provides emission abatement costs associated with the use of organic solvent-borne surface coatings for the following four industries.

- Automobiles and light-duty trucks
- Metal furniture
- Large appliances
- Metal coil coatings

These industries are considered together because of similarities in the coating processes employed, the nature of the resulting emissions, and the applicable control technologies. The chapter includes cost estimates for controlling VOC emissions to comply with both SIPs and NSPS.

This chapter has been revised to include the metal furniture industry and to update industry data for costing compliance with NSPS and current SIPs. Beverage can coating, for which an NSPS has been proposed, is not included in this report. Can coating emission control costs should be considered in the next version of this report.

Industry Characteristics

In 1980, approximately 96 million gallons (363 million liters) of surface coatings were consumed by the following four industries: automobiles and light duty trucks, metal furniture, major appliances and metal coil coatings.

A discussion of the specific industries follows.

Automobiles and light-duty trucks. In 1980 6,375,506 automobiles (SIC 3711) were assembled at 43 plants. Twenty-six percent of total output was produced in Michigan, 9.5 percent in Ohio, and 8.2 percent in Missouri. Fourteen other states accounted for the remaining 56.5 percent.

About 75 percent of total truck production (SIC 3713) consists of light-duty trucks, vehicles weighing 8500 pounds or less. Light-duty truck production was estimated to be 1,465,894 in 1980, with production taking place at 20 plants. Michigan accounted for about one-quarter of truck production, Ohio accounted for 15 percent, Missouri for 13 percent, and Kentucky for 8 percent. Twelve other states accounted for the remainder.

This chapter estimates pollution control costs for the 51 plants which produce automobiles and/or light-duty trucks. These plants consumed approximately 43 million gallons of surface coatings in 1980. This level of consumption is expected to remain relatively constant through 1990. In addition to the number of vehicles produced, three factors have affected the volume of coatings used by this industry. First, there has been a significant increase in the use of precoated metal. This decreases the amount of coatings applied by the vehicle manufacturer. Second, automobile size is decreasing, although this factor may be offset by the application of more paint per car for better durability and corrosion-resistance. Third, plastic parts that do not need a coating have already found much use in interior applications and are being developed for more exterior applications.

Metal Furniture. The metal furniture industry consists of the following categories:

- Metal household furniture (SIC 2514)
- Metal office furniture (SIC 2522)
- Public building and related furniture (SIC 2531)
- Metal partitions and fixtures (SIC 2542)

In 1976, about 1400 establishments made shipments of metal furniture valued at $3,657 million. Over half of those establishments were located in New York, California, Illinois, Pennsylvania, and Ohio, with the rest being spread throughout the country.

Manufacturers of metal furniture used about 20 million gallons of surface coatings in 1980. Industry growth depends on factors such as the number of new households, office building and remodeling construction, and government spending (for public facilities). EPA documents estimate an annual growth rate of 4 percent in shipments through 1985.

Large Appliances. In 1978, 95 companies operated 171 plants involved in the production of large appliances. They are classified as follows:

- Household cooking equipment (SIC 3631)
- Household refrigerators and home and farm freezers (SIC 3632)
- Household laundry equipment (SIC 3633)
- Household appliances, not elsewhere classified (SIC 3639)

These plants, located in 29 states, consumed approximately 13.5 million gallons of surface coatings in 1980. Their 1977 shipments were valued at $7,269 million with approximately 32,600,000 units produced.

Annual growth in shipments from 1967 to 1977 was about 3.0 percent, and economists predict an annual growth rate of about 2.6 percent through the 1980's. Growth will probably be in the production of dishwashers, trash compactors and microwave ovens, items that are far from the market saturation point.

Coil Coating. Coil coating is the application of organic coatings to flat metal sheet or strip that is packaged in rolls or coils. Coil coating (a small part of SIC 3479) is performed in approximately 109 plants with 147 coating lines. The plants are typically located in or near industrial areas. One-half of the plants are located in Illinois, Ohio, Pennsylvania, and California.

In 1977, North American shipments of coated metal coil were approximately 4 million tons (3.63 million Mg) and were valued at $3.5 billion. About 19 million gallons of surface coatings were used in coil coating in 1980. Major markets for coil coated metal include the transportation industry, the building products industry, and the packaging industry. Industry spokesmen indicate that large appliance manufacturers will also begin to make greater use of precoated metal stock.

The continual emergence of new end uses for the product enabled the industry to maintain a 10 percent average annual growth rate (in square meters of metal coated) between 1968 and 1977. The average growth rate from 1970 through 1980 was 5.2 percent. A 12 percent growth rate is forecast for the 1980s.

Pollutants and Sources

The surface coating process consists basically of three steps: application of the coating, air drying of the product after application (flashoff), and curing in an oven. All stages produce VOC emissions through evaporation of the organic solvent in the coating. The coatings may be applied by spray (the most commonly utilized method), dip, flow, or roller processes. About 60 percent of all the paint, shellac, lacquers, and primers used in 1980 were organic solvent-borne.

The volume of VOC emissions depends on coating content, application efficiency (which can vary from 10 to 100 percent), and add-on pollution controls, if any. The major sources of coating process emissions are usually the spray booth and its associated flashoff area.

Regulations

SIPs. Many of the early SIPs regulated VOC emissions from organic solvents either by setting limits on pounds per hour and pounds per day or by requiring that 85 percent control be demonstrated. These SIPs were patterned after Appendix B in the Code of Federal Regulations (40 CFR Part 51, Appendix B) or LA Rule 66 (the latter listed some solvents which were exempt from regulation). Some states also regulated surface coating facilities by a permit system, i.e., on a plant-by-plant basis.

Some newer SIPs are patterned after RACT described in EPA's Control Technique Guideline (CTG) documents. These SIPs establish, by industry, allowable VOC emissions per volume of coating solids applied. The state regulations of Michigan and Missouri contain company specific standards for surface coating operations in automobile and light-duty truck manufacturing.

The cost estimates assume that SIP compliance for the surface coating facilities of the metal furniture, large appliances, and metal coil coating industries was complete by December 1982. SIP compliance for automobile and light-duty truck surface coating facilities is assumed to be complete by 1987.

NSPS. NSPS have been promulgated for surface coating of automobiles and light-duty trucks, metal furniture, appliances, and metal coil coatings. Each of the NSPS allows for coating changes, process changes, and/or add-on controls to meet the emissions limits.

The NSPS for Surface Coatings of Automobiles and Light-Duty Trucks (45 FR 85410) was proposed on October 5, 1979 and promulgated on December 24, 1980. VOC emission limits are given for coatings used in each prime, guide (an extra coat needed if electrodeposition is used for the prime cost), and top coat. These limits are based on the use of waterborne coatings. Innovative technology waivers from NSPS for five automobile and light-duty truck surface coating operations were promulgated on February 4, 1983 (48 FR 5452). Cost impacts of these waivers are not estimated in this report.

The NSPS for Surface Coating of Metal Furniture (45 FR 79390) was proposed on November 28, 1980. The standard promulgated on October 29, 1982 (47 FR 49278) sets a standard for VOC emissions per liter of coating solids applied. The NSPS suggests various coatings changes, process changes, and emissions control devices.

An NSPS for Industrial Surface Coating: Appliances (45 FR 85085) was proposed on December 24, 1980. The standard promulgated on October 27, 1982 (47 FR 47778) sets a VOC emission limit per volume of coating solids used for each prime coat and each top coat operation within assembly plants where large appliance parts are coated with organic coatings. The standard does not apply to powder coatings. It may be met through use of coatings with higher solids content, application equipment with higher transfer efficiency, emission control devices, or combinations of these approaches. This standard applies to surface coating facilities used in the production of 10 different appliances.

NSPS for Metal Coil Surface Coating (45 FR 1102) was proposed on January 5, 1981, and promulgated on November 1, 1982 (47 FR 49606). The standard may be met by use of low VOC-content coatings, emission control devices, or combinations of the two.

Control Technology

The trend in the coatings industry has been toward development of greater product efficiency, including better protection or decoration for longer periods at lower cost. Present research is aimed toward replicating the performance of traditional (low solids, organic solvent-borne) coatings through the development of:

- low organic solvent materials (e.g., waterborne, high-solids, powder coatings)

and

- new application techniques for these materials (e.g., electrostatic spray of powder coatings, electrodeposition of waterborne coatings).

Most surface coating facilities are expected to control VOC emissions through the use of new technologies rather than through the conventional control techniques of incineration and carbon adsorption used in many other industries. These traditional methods are very expensive when VOC concentration is low, as is the case for many surface coating operations. The presence of personnel in spray booths means that large quantities of air must be injected to dilute the quantity of VOCs to limits tolerable to humans. If, instead, robots are used in spray booths (as is beginning to be seen in motor vehicle production), then the traditional control methods might become more economical. Although incineration of VOC emissions from ovens is technically feasible, ovens discharge only about 15 percent of the VOC emissions from a coating line. Thus, incineration of the bake oven exhaust goes only a limited way toward reducing VOC emissions.

A discussion of industry-specific control techniques follows.

Automobile and Light-Duty Trucks. Electrodeposition of waterborne coatings (EDP) for the prime coat provides superior corrosion protection. This report estimates costs for conversion to EDP (for the prime coat) for SIP compliance. However, it is assumed that new sources would choose the EDP process even without the NSPS; thus, no incremental cost is estimated for EDP for NSPS compliance. VOC reduction depends on the original process and coating material. A change to EDP from a 32 percent solids (68 percent solvent) primer applied by spray, for example, reduces VOC emissions by 80 percent.

Costs were estimated for two control alternatives for guide coats and top coats for compliance with SIPs and NSPS: waterborne coatings, and solvent-borne coatings followed by incineration of the bake oven exhaust.

Metal Furniture. In order to meet the SIP (CTG) limitations, manufacturers are assumed to use 60 percent solids coating for spray coating and waterborne coating for dip and flow coating, rather than the 35 percent solids organic solvent-borne coating associated with an uncontrolled facility. VOC emissions are thereby reduced by 60 to 67 percent. The cost estimates include conversion to waterborne coatings for 20 percent of existing spray plants.

Most new spray plants (80 percent) are expected to comply with NSPS through use of a high-solids coating. Capital costs for high-solids coatings are believed to be zero since different equipment is not required. O&M costs are negative (i.e., a savings is realized) since materials cost is lower for high solid coatings than for the conventional solvent-borne coating. The balance of spray plants will use either waterborne coating, powder coating, or a 60 percent solids coating (SIP complying) followed by incineration of bake oven emissions. Cost estimates were based on use of waterborne coating for this remaining 20 percent of the spray plants in order to simplify the costing. It was assumed that all dip plants would use electrodeposition of waterborne coatings to comply with NSPS. Cost estimates for NSPS compliance in flow coating plants were based on 80/20 waterborne coatings (80/20 is the water to solvent ratio). With NSPS controls in place, VOC emissions are reduced an additional 30 percent below the CTG level.

Major Appliances. Most SIP (CTG) limitations for existing sources in this industry are equivalent to the NSPS. This report estimated costs for two alternatives for prime coat emissions control: application of a high (62 percent) solids coating at a transfer efficiency of 60 percent and application of a waterborne coating by electrodeposition. These give 70 percent and 94 percent VOC reductions, respectively, and both meet NSPS and typical SIP requirements. Use of a high-solids coating at a 60 percent transfer efficiency was assumed for topcoat emissions control.

Metal coil coating. Since personnel can be isolated from the coil coating operation, VOC concentration can be high. NSPS compliance cost estimates were based on the use of thermal incineration with heat recovery (primary and secondary) and coating rooms for 85 percent of new sources. This control strategy reduces VOC emissions by 90 percent. It was assumed that approximately 15 percent of the coating lines would use waterborne coatings for SIP and NSPS compliance (also resulting in a 90 percent reduction). These control costs were assumed to be zero in EPA documents. Cost estimates for SIPs requiring 85 percent control were based on thermal incineration with heat recovery. Multiple zone incinerators and coating rooms were costed for compliance with the current SIPs. VOC emissions are reduced by 64 percent, using these controls.

Costing Methodology

EPA has estimated control costs for various model plants (by size and/or type) and control alternatives for each industry in the CTG and NSPS documents. The costs and capacity figures were fitted to exponential cost functions by linear regression of the logarithms. The resulting cost equations for capital and O&M were used to estimate total capital investment and annual O&M costs for each control alternative for each industry sector, using actual capacity figures and the control technique assumptions described above. Heat recovery credits were calculated separately for coil coating. Control costs are shown in Table A8.2.1.

As discussed above, costs are not included for the following plants: those spray plants that manufacture metal furniture and would comply with NSPS or SIPs by means of high-solids coatings and those plants that produce coated metal coil and would comply with NSPS or SIPs by means of waterborne coatings.

Table A8.2.1. Surface coating

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	115.47	146.84	335.00	679.20	845.80
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.76	20.94	15.97	60.02	159.44
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	120.23	167.78	350.97	739.22	1005.25
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	56.77	31.62	130.16	381.34	1101.68
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	4.55	6.56	11.51	36.47	139.76
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	61.32	38.18	141.67	417.81	1241.44
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	48.69	17.08	110.30	325.69	875.28
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	5.49	3.94	14.02	32.75	92.33
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	54.18	21.02	124.32	358.43	967.61
TOTAL ANNUAL COSTS	115.49	59.20	265.99	776.24	2209.05

Chapter A8.3 Dry Cleaning Industry

The dry cleaning industry is a significant source of volatile organic compounds (VOC), a precursor of oxidants. Since dry cleaning facilities are concentrated in urban areas where ambient oxidant standards are likely to be exceeded, there are increasing efforts to regulate this industry. Revisions of this chapter included adjusting pollution control costs to 1981 dollars, editing and updating discussion of regulations, and updating industry data.

Regulations

Although no NSPS has been promulgated for this industry, a NSPS for perchloroethylene dry cleaning was proposed on November 25, 1980, (45 FR 78174) and a NSPS for petroleum solvent dry cleaning is currently under development. Both of these regulations would control VOC emissions. The proposed NSPS for perchloroethylene dry cleaning would limit process wastes and leaks and require the use of a carbon adsorber or refrigeration equipment to control emissions from exhausts and vents.

Dry cleaning plants are subject to VOC regulations in SIPs. An increasing number of states have regulations that limit the VOC emissions from handling and use of organic solvents. Historically, these regulations were patterned after Los Angeles' Rule 66 or Appendix B (40 CFR 51, App. B). Both of these regulations have pounds-per-day and pounds-per-hour limits, but compliance is achieved if 85 percent control is demonstrated.

In the late 1970's and early 1980's, EPA issued draft and final control technique documents covering control of volatile organic emissions from both types of dry cleaning operations as guidance to states for setting standards for this industry achievable with RACT. States with ozone non-attainment areas in 1977 were required to revise their SIPs to include VOC regulations for perchloroethylene dry cleaning facilities by January 1981. States that were unable to demonstrate attainment for ozone by the statutory deadline of December 31, 1982, could request extensions for attainment of the standard. States granted such an extension are required to submit a further revised SIP including VOC regulations for petroleum solvent dry cleaning facilities.

In the past, the use of the synthetic solvent, perchloroethylene, instead of a petroleum solvent, such as Stoddard, was encouraged as a means of reducing the oxidant problem even when control of the perchloroethylene was not anticipated. The synthetic solvent was judged to be less reactive in the atmosphere and thus would tend to reduce photochemical oxidant formation. However, in 1976 and 1977 EPA released statements (41 FR 5350 and 42 FR 35315) recommending that controls be imposed on perchloroethylene emissions because (1) even compounds having low reactivity can form considerable amounts of oxidant under certain atmospheric conditions and

(2) perchloroethylene has been reported to have adverse health effects. Both the health effects and photoreactivity of perchloroethylene are currently under study.

Industry Characteristics

There are primarily two types of dry cleaning installations that release organic-solvent vapors resulting in the formation of photochemical oxidants in the atmosphere. About 70 percent use synthetic solvents such as perchloroethylene, and the remainder use petroleum solvents such as Stoddard.

The trend in dry cleaning operations has been towards increasing business for "laundromat" facilities and industrial establishments, while business in the commercial sector (small neighborhood dry cleaning shops) has declined. The number of facilities predominantly offering dry cleaning services fell from about 28,000 in 1972 to 22,000 in 1977. This 5 percent annual decline reflected the increased use of synthetic fibers in clothing, which reduced the need for dry cleaning. Because consumer demand for synthetics has stabilized, we assume that the number of dry cleaning plants will remain relatively constant in the 1980's.

The dry cleaning plants covered in this chapter are classified into SIC 7216. Other laundry facilities, which are classified into SIC 7211 (power laundries), 7218 (industrial launderers), and 7213 (linen supply), also operate some dry cleaning machines. The value of receipts for SIC 7216 rose only slightly from $1.8 to $1.9 billion between 1972 and 1977.

Pollutants and Sources

In perchloroethylene plants, average solvent losses have been estimated to be about 10-12 kg of solvent per 100 kg of clothing. Unlike petroleum plants, where no emission controls are used, many dry cleaning operations using perchloroethylene solvents have vapor adsorbers to reduce solvent usage. For adsorber-equipped plants, the solvent losses are approximately 5 kg per 100 kg of clothing. Other plants are equipped with a regenerative filter and a muck cooker. For these facilities, solvent losses average about 8 kg of solvent per 100 kg of clothing.

Because there is no solvent recovery during the drying cycle nor from the filter muck, petroleum plants have much higher solvent losses than synthetic plants. Emissions for petroleum dry cleaners are estimated to average 23-29 kilograms of solvent per 100 kilograms of materials cleaned. At the present time, very few control systems are known to be operating in petroleum plants in the U.S.

Control Technology

Historically, the dry cleaning industry has met emission standards by replacing petroleum solvents with synthetic solvents and using equipment that recycles these synthetic solvents. Recycling is encouraged because of the high cost of these solvents.

Fire-hazards and the lack of economic incentives or air pollution regulations are the primary reason why carbon adsorbers are not widely used in the petroleum dry cleaning industry. The low cost of petroleum solvents in the past has provided little motivation for controlling losses.

The high cost of perchloroethylene solvent has made carbon adsorption attractive to the synthetic solvent users. Presently about 35 percent of synthetic solvent plants are equipped with adsorption units. Maintenance, however, is frequently very poor.

Carbon adsorption can be used in perchloroethylene plants to reduce vented emissions from the washer, dryer, storage tanks, distillation systems, and chemical separators to a concentration less than 100 ppm. The application of add-on controls and better house-keeping practices can reduce annual dry cleaning solvent consumption by an average of 60-70 percent.

Because of the higher capital investment and operating costs required for emissions controls on petroleum-solvent plants, it is believed that most new plants will use synthetic solvent and that many of the petroleum-naphtha solvent plants will convert to synthetic solvent operations by the mid-1980's. Increasing solvent costs will provide an incentive for more effective evaporative emission control.

Costing Methodology

Control costs are aggregated in Table A8.3.1. The costing methodology is largely based on data given in a 1977 draft EPA document but using the following conditions:

- only industrial and commercial plants will be controlled (coin-operated plants will not be controlled)
- petroleum solvent plants will convert to other solvents
- compliance will occur in the years 1982 to 1987 by virtue of Air Quality/SIP and NSPS timing
- thirty-five percent of all perchloroethylene plants are considered to install carbon adsorption units for reasons of solvent recovery rather than air regulations.

Table A8.3.1. Dry cleaning industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .291E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	229.80	656.58
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	13.98	57.82
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	243.78	714.39
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	53.43	619.76
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	3.41	41.80
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	56.83	661.56
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	11.31	131.17
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.38	4.70
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	11.69	135.87
TOTAL ANNUAL COSTS	0.0	0.0	0.0	68.53	797.43

Chapter A8.4 Printing Ink Manufacture

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and expanding the discussion of applicable regulations.

Regulations

No NSPS has been promulgated for printing ink manufacture. The volatile organic compound (VOC) and particulate emission standards in SIPs apply to this industry. An increasing number of states are including general emissions limits for photochemically reactive hydrocarbons in their SIPs. Most of the regulations are patterned after Appendix B (40 CFR 51, App. B) or after Los Angeles' Rule 66. Although Rule 66 sets emission limits, the standard can also be met if uncontrolled emissions are reduced by 85 percent. Appendix B states that the 85 percent reduction is achievable with RACT. Many states also pattern their general particulate standards after the suggested RACT process weight tables in Appendix B.

Industry Characteristics

The printing ink manufacturing industry is similar in many respects to the paint manufacturing industry, although it is considerably smaller in size. The industry sector described in this chapter is contained in SIC 2893. Captive shops and their production are part of SIC 27 and are not included in this chapter.

The major components of ink include drying oils, resins, varnish, shellac, pigments, solvents, and many specialty additives. The three principal ingredients, vehicles (or varnishes), pigments, and solvents, are mixed together thoroughly to produce a uniform dispersion of pigments within the vehicle. The mixing is accomplished using high-speed mixers, ball mills, three-roll mills, and other types of mills.

Annual printing ink production in the United States now exceeds a billion pounds. The principal types of printing inks manufactured by the industry are lithographic, letterpress, gravure, flexographic, and special. In 1976, the industry was estimated to be composed of about 460 plants with about 9000 employees involved in production. About 40 percent of the plants had less than ten employees and about 70 percent less than 20 employees. The historical growth rate of industry sales has been reported in 1976 as having been about 5 percent per year.

Pollutants and Sources

Varnish or vehicle preparation by heating is the largest source of emissions from printing ink manufacturing. Air pollutants from printing ink manufacturing are gaseous organic (hydrocarbons) materials originating from the varnishes and organic solvents, and particulates from pigment mixing operations. About 120 pounds of gaseous organics are emitted per short ton (2000 pounds) of product. About 2 pounds of particulate are emitted per short ton of pigment dispersed.

Control Technology

Reduction of the gaseous organic emissions from printing ink formulation by 85 percent, which will meet practically all SIP's, can be accomplished by thermal combustion, catalytic combustion, flame combustion, or adsorption. Incineration of gaseous organic or hydrocarbon emissions from ink formulating operations using thermal afterburners has proved to be the most effective control method and one that is relatively free of maintenance problems. Thermal incineration using a direct-fired afterburner (with heat exchange) achieves control efficiencies of 95 percent, and was considered the preferred method for controlling the gaseous organic emissions. Catalytic afterburners, although capable of adequate control, still present some technical operating problems.

Fabric filters (baghouses) are suitable for control of particulate emissions from pigment mixing. Particulate removal efficiencies of greater than 95 percent are achieved readily.

Costing Methodology

Estimates of pollution control costs for the printing ink formulating industry were based on assumed compliance of 230 large plants in the industry. The model plant for the large-plant category, which represents about 90 percent of industry production, had an annual production of 3,750,000 pounds in 1976. The cost of the above technology for these plants is indicated in Table A8.4.1. Compliance with SIPs was assumed to occur over the period from before 1970 through 1987.

Table A8.4.1. Printing ink manufacture

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .164E+07

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	2.85	24.23	9.80	20.87	47.15
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.85	24.23	9.80	20.87	47.15
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	5.54	14.79	15.18	32.84	66.36
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	5.54	14.79	15.18	32.84	66.36
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	15.56	36.36	41.46	92.93	189.07
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	15.56	36.36	41.46	92.93	189.07
TOTAL ANNUAL COSTS	21.10	51.15	56.63	125.77	255.44

Chapter A8.5 Synthetic Fiber (Nylon) Manufacture

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars, editing the discussion of regulations, and reorganizing the industry description.

Regulations

No NSPS has been promulgated for this industry. General hydrocarbon standards in SIPs apply to synthetic fiber manufacturing plants. Most state regulations of hydrocarbon emissions are patterned after Appendix B (40 CFR 50, App. B) or after Los Angeles Rule 66. Both of these regulations have pounds-per-day and pounds-per-hour limits, but compliance is achieved if 85 percent control is demonstrated.

The NSPS underdevelopment for synthetic fiber production plants will cover only those plants that use an organic solvent in the process. Production of fibers such as acrylic, modacrylic, cellulose acetate, and spandex will be included, but not nylon production. In the next edition of this report, this chapter will be revised to include fibers that will be covered by the NSPS.

Industry Characteristics

Nylon was probably the first important truly synthetic fiber produced. It accounted for 26 percent of total synthetic fiber production in 1976. Nylon fibers have applications in all major fiber use areas, including carpeting, hosiery, apparel, and tire cord.

The total production of all nylon fibers in 1976 amounted to about 2,150 million pounds. The estimated plant capacity for 1976 was 2,675 million pounds. Of the 39 plants on line in 1976, 11 plants were relatively small and had plant capacities of 4.4 million pounds or less. The average plant capacity for the small plants was 2.6 million pounds per year. The average plant capacity for the remaining 28 plants was calculated to be 95 million pounds per year. This average capacity value was taken to be representative of a model large plant and was used to estimate emission control costs for nylon fiber manufacture.

Process Description

Melt spinning is used to convert bulk nylon polymer chips into fiber materials. Polymer chips are melted in a heated screw extruder, processed in a nitrogen atmosphere, then filtered through a series of metal gauzes or a layer of graded sand. The filtered molten polymer is then extruded under pressure at a constant rate through nickel or stainless steel spinnerets. Extrusion is followed by air cooling. For Nylon 66 fibers, the filaments pass through a steam conditioning tube before converging. After the fiber is converged, it is given further treatments which are dictated by the fiber's intended end use. These treatments generally include lubrication, drawing, and fiber modification, with the end product being the finished fiber.

Pollutants and Sources

The source of gaseous emissions from nylon fiber manufacturing plants is the fiber finishing (drying) operation. Uncontrolled hydrocarbon and oil vapor emissions from nylon fiber production are 7.0 and 15.0 pounds (respectively) per short ton of nylon fiber produced.

Control Technology

Reduction of gaseous organic emissions from nylon fiber production by 85 percent, which will meet most SIP's, can be readily accomplished in a direct-fired afterburner. Applicable control methods include incineration and carbon adsorption. Direct fired afterburners can generally achieve 98-99 or more percent reduction of emissions, whereas carbon adsorption systems can reduce emissions by about 80 to 95 percent. Because of the greater degree of emission control provided by use of the direct fired afterburner, incineration was selected as the control method for the emissions from nylon fiber manufacturing operations.

Costing Methodology

Pollution control costs for the nylon fiber industry were estimated using a model plant. The model plant selected was considered representative of 28 large plants each with an annual capacity for producing 95 million pounds of nylon fiber. These 28 large plants accounted for 99 percent of the plant capacity in the industry.

The estimated costs of control developed on the above basis are given in Table A8.5.1. An assumed compliance schedule was used which distributed compliance over the period from 1970 to 1987.

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .347E+06

Table A8.5.1. Synthetic fiber (nylon) manufacture

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.14	2.33	0.45	1.22	3.48
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.14	2.33	0.45	1.22	3.48
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.42	1.51	1.24	2.57	4.99
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.42	1.51	1.24	2.57	4.99
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	1.23	3.87	3.55	7.59	14.71
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.23	3.87	3.55	7.59	14.71
TOTAL ANNUAL COSTS	1.66	5.38	4.79	10.16	19.70

Chapter A8.6 Lead-Acid Storage Batteries

This chapter has been added to the Cost of Clean Air report because emissions from lead-acid battery manufacturing facilities present a significant pollution control problem. Available data indicate that uncontrolled lead emissions may cause symptoms of lead poisoning to appear in certain individuals in the vicinity of battery plants. These plants generally are located near residential areas. The chapter includes cost estimates of controlling lead-bearing and non-lead bearing particulates for compliance with SIPs and NSPS.

Industry Description

The lead-acid storage battery manufacturing industry is the largest single consumer of lead in the United States, accounting for approximately 62 percent of domestic lead consumption in 1980 (Ref. 6, p. 33). There were about 190 lead-acid battery plants in 1977. Plants owned by the six largest companies produced 70 percent of the total output (Ref. 2, p. 8-1).

Battery plants are generally located in urban areas near outlets for their products. The larger plants tend to have secondary smelting facilities and/or lead oxide production facilities; smaller firms tend to purchase the lead constituents (Ref. 2, p. 3-1).

There are two major types of lead-acid batteries: (1) starting-lighting-ignition (SLI) batteries used in automobiles, golf carts, recreational vehicles, and aircraft (SIC 36911) and (2) industrial storage batteries for low voltage power systems, industrial fork lift trucks, etc. (SIC 36912). SLI batteries make up 80 percent of the battery market; 80 percent of SLI batteries are used in automobiles (Ref. 2, p. 3-6).

Total lead-acid battery production was about 87 million units in 1979 (Ref. 5, p. 109). In 1977, the value of shipments was $1,983 million (Ref. 7, p. 36 F-12). Throughout the 1970's, the replacement sector accounted for approximately 80 percent of automobile battery production (Ref. 5, p. 109). Current demand for replacement batteries is dependent upon automobile sales three to four years ago, automobile sales six to eight years ago, and extremes in the weather (Ref. 4, p. M180). This replacement market is forecast to grow, since owners are keeping their automobiles longer (Ref. 8).

The decline in new car sales and the recession of the early 1980's have caused uncertainty regarding growth of the lead-acid battery industry. Between 1968 and 1977 the industry grew at an average rate of 4.9 percent per year (Ref. 2, p. 8-7) but output declined in 1980 and 1981 (Ref. 9).

Industry sources suggest a three to eight percent growth rate when the economic downturn ends. Possible growth areas include recreational vehicles, trucks and commercial vehicles, and electric cars (if powered by lead-acid batteries (Ref. 8).

According to EPA personnel, new capacity will probably be created by expanding the larger existing plants (those with capacities of more than 6500 batteries per day (Ref. 2, p. 3-8).

Pollutants and Sources (Ref. 2, Chapter 3,4)

The manufacturing of lead-acid batteries has five distinct steps: lead oxide manufacturing, paste mixing, grid casting, the three-process operation (including plate stacking, element burning, and battery assembly), and formation.

At approximately 20 percent of the plants there is a sixth process, lead reclamation, in which scrap lead from defective batteries is recycled. Generally, these six processes and their facilities may be considered independent of one another in that there is not a continuous flow of materials from one to another.

The major air pollution problem associated with lead-acid battery manufacture is the emission of particulates, 50 percent of which are lead-bearing. These particulates are emitted from all but the formation process. In addition, sulfuric acid mist is emitted during formation. The manufacture of the new "no maintenance" battery yields the same amount and type of pollutants.

Regulations

SIPs. The various state requirements for particulate control apply to the lead-acid battery manufacturing industry. Those requirements are often expressed in terms of allowable emission rates for given process weight rates. SIPs may also specify any additional controls needed to meet the lead NAAQS. EPA now requires states to expand their SIPs to regulate certain specific lead sources, one of which is lead-acid battery plants producing at least 2,000 batteries per day (40 CFR part 51 subpart E). State requirements for sulfuric acid emission control also affect lead-acid battery manufacture.

NSPS. EPA promulgated the first NSPS for sources of lead pollution on April 16, 1982 (47 FR 16564, 40 CFR 60.370). The proposed standards regulate the five main lead-emitting operations in a lead-acid battery plant by setting a lead emissions limit for each operation. There is also a lead emissions limit for "other lead emitting operations." The regulation covers plants with the design capacity to produce in one day batteries that would contain, in total, at least 5.9 Mg of lead.

As discussed in the NSPS proposal (45 FR 2790), sulfuric acid mist from lead-acid battery plants may be regulated in the future when quantitative data on those emissions are available. Such a NSPS would establish sulfuric acid mist as a designated pollutant, and states would also be required to regulate sulfuric acid mist emissions from existing lead-acid battery plants.

Control Technology (Ref. 2, Chapter 4)

An estimated 60 percent of the particulate control devices used by the lead-acid battery industry are baghouses with control efficiencies ranging from 96 to 99.8 percent; the remaining 40 percent consist of scrubbers and cyclones with reported efficiencies ranging from 50 to 98 percent.

Most plants vent the stacking, burning, and assembly operations (the three-process operation) into a common duct prior to cleaning the gases. Other plants clean the exhaust from paste mixing and the three-process operation with a common system. Lead oxide production facilities use mechanical collectors and a baghouse in series to remove the product lead oxide from the carrier air stream. The baghouse is considered as both process equipment and air pollution control equipment. The exhaust gas stream from the lead reclamation process is similar to the grid casting exhaust gases in that both are characterized by high temperatures and lead fumes. It is common for these two gas streams to be treated by one control device, generally a low-energy wet scrubber. Fabric filters are not presently used to control this stream in any battery plant, but they have been proven effective in controlling emissions from similar processes in other industries.

The control technologies for NSPS compliance are impingement scrubbers for the grid casting and lead reclamation facilities and fabric filters for the other facilities. NSPS costs are estimated for expansions of larger (6,500 batteries per day) existing plants. The NSPS cost for lead oxide manufacturing includes only the incremental cost of a baghouse with a two to one air to cloth ration relative to one with a three to one air to cloth ration, which is assumed to be part of the process equipment. The NSPS costs do not include the costs for impingement scrubbers on the paste mixing and lead reclamation facilities, which are required for SIP compliance.

The control technology costed for SIPs includes impingement and entrainment scrubbers for the paste mixing and lead reclamation processes. Because of their high process weights the other processes are able to comply with the typical SIP particulate regulation without control devices (Ref. 2, p. 8-16). The uncontrolled formation facility also complies with SIPs (Ref. 2, p. 7-9). This report assumes that all SIP particulate controls were in place by 1978.

Costing Methodology

EPA has estimated costs for the SIP and NSPS controls for various sized model plants in its Background Information Documents for the proposed and promulgated NSPS. These cost and capacity figures were fitted to an exponential cost function by linear regression of the logarithms. The resulting cost equations for capital and O&M were employed to generate total capital investment and annual O&M costs, based on estimated plant capacities. Control costs are shown in Table A8.6.1.

Table A8.6.1. Lead-acid storage batteries

AIR POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS)	1981	1970-78	1979-81	1979-84	1981-90
CAPITAL IN PLACE (KIP):	.0				
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	21.35	0.0	0.0	15.84
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.02	0.08
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	21.35	0.0	0.02	15.92
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	2.81	11.66	8.42	16.84	28.82
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.00	0.05
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.81	11.66	8.42	16.84	28.87
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	3.48	13.62	10.44	20.87	34.79
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.01	0.18
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	3.48	13.62	10.44	20.89	34.97
TOTAL ANNUAL COSTS	6.29	25.28	18.86	37.73	63.83

Chapter A9. Forest and Agricultural Products Industries

For the purpose of this report, the Forest and Agricultural Products Industries are defined as those establishments which process products grown on the land. Those covered here are:

- Kraft Pulp Industry
- Neautral Sulfite Semichemical Paper Industry
- Grain Elevators
- Feed Mills
- Plywood Veneer

The costs of air pollution control for these categories of industry are listed in table A9. The industries and more specific details of controls and costs are discussed in the following sections.

TABLE A 9. FORREST & AGRICULTURAL PRODUCTS INDUSTRIES AIR POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 9. 1	KRAFT PAPER	71.88	1323.53	212.40	391.73	472.76
A 9. 2	NSSC PAPER	0.0	72.03	0.0	0.0	0.0
A 9. 3	GRAIN ELEVATORS	24.24	441.96	155.86	233.45	497.74
A 9. 4	FEED MILLS	10.95	567.99	31.89	66.83	414.71
A 9. 5	PLYWOOD VENEER	2.05	2.43	4.89	11.80	19.31
	TOTAL INVESTMENT	109.12	2407.95	405.04	703.82	1404.52

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A 9. 1	KRAFT PAPER	347.32	1018.31	993.41	2125.26	3744.73
A 9. 2	NSSC PAPER	15.52	39.50	45.38	91.95	146.74
A 9. 3	GRAIN ELEVATORS	14.95	37.84	41.08	92.17	193.50
A 9. 4	FEED MILLS	136.78	436.32	396.58	824.05	1489.55
A 9. 5	PLYWOOD VENEER	1.66	1.06	3.60	11.77	35.15
	TOTAL ANNUAL COSTS	516.24	1533.03	1480.06	3145.19	5609.66

Chapter A9.1 Kraft Pulp Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS for kraft pulp mills (40 CFR 60.280) was promulgated on February 23, 1978, and revised in 1978 and 1979. The regulation sets limits for particulate emissions from recovery furnaces, smelt dissolving tanks, and lime kilns and opacity limits for recovery furnaces. It also regulates total reduced sulfur (TRS) emissions from lime kilns, smelt dissolving tanks, cross recovery furnaces, straight kraft recovery furnaces, digester systems, brown stock washer systems, multiple effect evaporator systems, black liquor oxidation systems, and condensate stripper systems.

Since TRS is not a criteria pollutant, the establishment of NSPS for TRS required the states (under Section 111 (d) of the Clean Air Act) to regulate emissions of this "designated" pollutant from existing kraft pulp mills. EPA provided guidance to the states for establishing these standards in a March 1979 control technique guideline document. As a result, states with kraft pulp mills are including TRS limits for the existing facilities in their regulations.

The general particulate standards in SIPs apply to kraft pulp mills. Most are patterned after the process weight rates in Appendix B (40 CFR 51, App. B), which were suggested as achievable with RACT. Several states have regulations covering particulate and TRS emissions from specific sources at kraft pulp mills. At least one state also regulates sulfur oxide emissions while another limits organic vapors.

Industry Characteristics

This chapter discusses air pollution control costs for kraft pulping, the predominate chemical pulping process; chapter 9.2 covers neutral sulfite semichemical (NSSC) pulping. Wood pulping processes separate the fiber from other wood constituents and prepare it for further use in manufacturing paper products. Some pulping methods rely primarily on mechanical processes, others use chemical processes, and others (the semichemical methods) combine aspects of both mechanical and chemical pulping.

The kraft pulp industry has a capacity of about 40 million short tons of pulp per year, with little scheduled capacity growth. In 1979, there were 121 kraft mills in the U.S., with the majority located in the South.

Kraft pulp is used in the production of linerboard, solid-fiber board, high-strength bags, wrapping paper, high grade white paper, food-packaging materials, and other products. The kraft pulp industry and other pulping processes are categorized in SIC 2611.

Pollutants and Sources

Kraft pulping, in simplified terms, consists of seven separate processes. The digesting liquor in this process flow is a solution of sodium hydroxide and sodium sulfide. The spent liquor (black liquor) is concentrated, then sodium sulfate is added to make up for chemical losses, and the liquor is burned in a recovery furnace, producing a smelt of sodium carbonate and sodium sulfide. The smelt is dissolved in water to form green liquor, to which is added quicklime to convert the sodium carbonate back to sodium hydroxide, thus reconstituting the cooking liquor. The spent lime cake (calcium carbonate) is recalcined in a rotary lime kiln to produce quicklime (calcium oxide) for recausticizing the green liquor.

Main emission sources in the kraft process are the recovery furnace, lime kiln, smelt dissolving tank, and the power boilers. The kraft pulping economics depend upon reclamation of chemicals from the recovery furnace and lime kiln. Hence, emissions from these processes are controlled to minimize losses of chemicals.

Particulates and gasses are emitted from the various sources of the kraft process. Numerous variables affect the quality and quantity of emissions from each source of the kraft pulping process. There are several sources of emissions in the process and the applicable control technology and attainable efficiencies of the control methods depend on the quantity and quality of emissions. The gaseous emissions occur in varying mixtures, and are mainly hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and some sulfur dioxide. The sulfur compounds are detectable at a concentration of a few parts per billion. The particulate emissions are largely sodium sulfate, calcium compounds, and fly ash.

The rates of uncontrolled and controlled emissions of particulates, total reduced sulfur (TRS), and sulfur dioxide from various sources of kraft pulping processing are shown in Table A9.1.1.

Most states do not have emission regulations for pulp and paper making. For this study it has been assumed that all the states would adopt the most stringent current state regulations--those of Oregon and Washington. Costs for compliance are based on all mills meeting these regulations. The regulations include the following control provisions:

(1) Total reduced sulfur (TRS) compounds from the recovery furnace: No more than 1 kg/ADMT (2 lb/ADT) (1972) to be reduced to no more than 0.25 kg/ADMT (0.5 lb/ADT) by 1975.

(2) Noncondensible gases from the digesters and multiple-effect evaporators: collected and burned in the lime kiln or proven equivalent.

Table A9.1.1. Rates of emissions from Kraft process
(In kg/ADMT with lb/ADT in parentheses) 1/

Process	Particles	TRS	Sulfur dioxide
	Uncontrolled		
Digester	0.0 (0.0)	0.72 (1.44)	Trace
Washer	0.0 (0.0)	0.05 (0.10)	Trace
Multiple effect evaporator	0.0 (0.0)	0.18 (0.36)	Trace
Recovery furnace	60.0 (120.0)	2.95 (5.90)	1.2 (2.4)
Smelt tank	7.8 (15.6)	0.05 (0.10)	Trace
Lime kiln	34.0 (68.0)	0.22 (0.44)	Trace
Power boiler 2/	35.3 (70.6)	0.0 (0.0)	19.7 (39.4)
Totals	137.1 (274.2)	4.17 (8.34)	20.9 (41.8)
	Controlled		
Digester	0.0 (0.0)	Trace	Trace
Washer	0.0 (0.0)	Trace	Trace
Multiple effect evaporator	0.0 (0.0)	Trace	Trace
Recovery furnace	2.00 (4.00)	0.25 (0.50)	1.2 (2.4)
Smelt tank	0.25 (0.50)	Trace	Trace
Lime kiln	0.50 (1.00)	Trace	Trace
Power boiler	2.47 (4.94)	0.0 (0.0)	10.5 (21.0)
Totals	5.22 (10.44)	0.25 (0.50)	11.7 (23.4)

1/ ADMT = Air-dried metric ton (ADT = Air-dried short ton).

2/ Fuel requirement = 3.26 x 10^{10} joules/ADMT (3.09 x 10^{7} Btu/ADT). Coal provides 35%, oil 27%, gas 26%, and bark/wood 12% of the energy. Sulfur content = coal 1.9% and oil 1.8%. Ash content = coal 8.1% and bark/wood 2.9%.

(3) Particulates from the recovery furnace: no more than 2 kg/ADMT (4 lb/ADT).

(4) Particulates from the lime kiln: no more than 0.5 kg/ADMT (1 lb/ADT).

(5) Particulates from smelt tank: no more than 0.25 kg/ADMT (0.5 lb/ADT).

(6) Emissions from power boiler will meet the Federal emission standard.

Industry Costs

The costs reported here were adopted empirically from an Economic Impact study published in May, 1977 (EPA-230/3-76-014). Aggregate costs reported there were adapted using estimated schedules of compliance; compliance costs for new plants were assumed to be associated largely with Kraft mills. The aggregated costs developed on this basis are given in Table A9.1.2.

Table A9.1.2. Kraft pulp industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .695E+06

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	71.88	1323.53	212.40	391.73	472.76
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	201.93	592.20	577.61	1235.81	2177.52
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	145.39	426.12	415.80	889.45	1567.22
TOTAL ANNUAL COSTS	347.32	1018.32	993.41	2125.26	3744.74

Chapter A9.2 Neutral Sulfite Semichemical Paper Industry

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

No NSPS governs this industry. Neutral Sulfite Semichemical (NSSC) paper mills are subject to sulfur dioxide and particulate emission standards in SIPs. Most of the limits in SIPs are patterned after standards suggested in Appendix B (40 CFR 51, App. B) as achievable with RACT.

Appendix B presents limits for sulfur oxides, expressed as sulfur dioxide, for several processes of sulfite pulp mills, including blow pits, washer vents, storage tanks recovery systems, and digesters. The Appendix B process weight rate limits for particulate emissions from process industries also apply to these mills. A few states, however, have set particulate as well as sulfur dioxide standards specifically for sulfite mills.

Industry Characteristics

Current industry capacity is about 3.95 million dry metric tons (4.36 million short tons) per year. Most of new capacity is replacement or expansion capacity due to the high cost of completely new mills. Mills are currently operating at between 85 and 90 percent of capacity, so the industry has some marginal capacity to fill limited increases in demand.

Semichemical pulps are produced by digesting pulp wood with reduced amounts of chemicals, followed by mechanical treatment to complete the fiber separation. The most prevalent semichemical pulping process is the neutral sulfite semichemical process. In this process, sodium sulfite in combination with sodium bicarbonate, or ammonium sulfite buffered with ammonium hydroxide, are used as cooking chemicals. These cooks are slightly alkaline in contrast to the highly alkaline kraft, and highly or moderately acidic sulfite cooks. The semichemical pulping processes are used for production of high-yield pulps ranging from 60 to 85 percent of dry wood weight charged to the digestion vessel, and can include kraft and sulfite processes suitably modified to reduce pulping action in order to produce higher-than-normal yield pulps.

Semichemical pulps are used in preparing corrugating medium, coarse wrapping paper, linerboard, hardboard, and roofing felt, as well as fine grades of paper and other products.

Pollutants and Sources

Discussions and calculations of air emissions from the neutral sulfite semichemical (NSSC) process are limited to particulate and sulfur dioxide. The used cooking liquors are discharged to sewers or in some cases they are evaporated and cross-recovered with an adjacent kraft mill or treated in a fluidized-bed system. In this study, fluidized-bed combustion was assumed for the liquor treatment. Emissions are summarized in Table A9.2.1.

Control Technology

For the purposes of this report it was assumed that particulate emissions from the recovery furnace and power boilers burning coal and bark/wood, and sulfur dioxide emission from power boilers burning high-sulfur coal and oil, were subject to control. To meet the particulate emissions standard for recovery furnaces, a control efficiency of at least 90 percent is required for the control system. A sodium-based, double alkali system was assumed for the control of sulfur dioxide from coal- and oil-burning power boilers.

Control methods for new plants were selected as follows:

Process	Pollutant	Control Methods
Recovery Furnace	Particulate	Electrostatic Precipitator
Power Boiler	Particulate	Electrostatic Precipitator
	Sulfur Dioxide	Double alkali

Costs are summarized in Table A9.2.2. Since cost data were taken from a specific source, rather than developed within the computer model, new plant costs are included with existing plants.

Table A9.2.1. Controlled and uncontrolled emissions from various processes in the NSSC paper industry (in kg per ADMT with lb per ADT in parentheses) 1/

Process	Particulate	Emissions	Sulfur dioxide emissions	
	At 1971 control levels	With legislated controls	At 1971 control levels	With legislated controls
Recovery furnace	20.0 (40.0)	2.0 (4.0)	0.01 (0.02)	0.01 (0.02)
Power boiler	35.3 (70.0)	2.47 (4.94)	19.7 (39.4)	10.5 (21.0)
Totals	55.3 (110.6)	4.47 (8.94)	20.71 (41.42)	10.5 (21.0)

1/ ADMT = Air-dried metric ton (ADT = air-dried short ton).

Source: Atmospheric Emissions from the Pulp and Paper Manufacturing Industry - Report of NCASI - EPA Cooperative Study Project, Technical Bulletin No. 69, February 1974.

Table A9.2.2. Neutral sulfite semichemical paper industry

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .347E+06

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	72.03	0.0	0.0	0.0
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	9.47	31.83	28.41	56.82	86.22
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.0	0.0	0.0	0.0	0.0
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	6.05	7.68	16.97	35.13	60.52
TOTAL ANNUAL COSTS	15.52	39.50	45.38	91.95	146.74

Chapter A9.3 Grain Elevators

This chapter and Chapter A9.4, Feed Mills, discuss particulate emissions control from two stages of the feed and grain industry. The cost for grain elevator compliance with SIPs and NSPS is estimated in this chapter.

Industry Characteristics

The grain distribution system effects the transfer of grain from farm to mill to final user. Grain elevators perform a storage and transfer function in this system. This chapter covers only grain storage facilities at distribution sites, not those located in grain or feed mills.

There are two main classifications of grain elevators--country and terminal. Most country elevators receive grain by truck from nearby farms for storage or shipment to terminal elevators or processors (mills). Terminal elevators are generally larger than country elevators and are located at significant transportation or trade centers. Port terminals transfer grain to ships for export to foreign countries, whereas inland terminals transfer grain by truck and rail car to processors and to other terminals.

Based on Department of Agriculture statistics, we have estimated that about 9,000 grain elevators with a total capacity of about 6.0 billion bushels were affected by air pollution control regulations in January 1982. Country elevators account for 70 percent of capacity, and terminals the balance. Port terminals represent 15 percent of all terminals with the remainder being inland terminals.

Country elevator capacity is expected to continue to grow at the 3.5 percent annual rate experienced during the past decade, whereas terminal capacity will continue to remain relatively constant. Smaller country elevators are being replaced with larger elevators, which have a greater throughput. Existing terminals are being expanded to transfer a larger throughput of grain. This expansion in the number of terminals is expected to occur at the rate of 1 percent per year.

Grain elevators are classified into SIC 5153, grain wholesale facilities. In addition to country and terminal elevators, SIC 5153 includes other merchants marketing grain. The Census of Wholesale Trade reported about 9000 establishments in this SIC with sales of $68.5 billion in 1977.

Emission Sources and Pollutants

In addition to storage and distribution, grain elevator operations include the screening, cleaning, and drying of the grain in order to prevent spoilage during storage. The major sources of emissions at a grain storage facility are unloading and loading rail cars, trucks, and barges; conveying grain within the facility; and screening, cleaning, and drying.

Most of the air emissions are particulates in the form of grain kernels, dirt, and dust. The level of emissions depends on the characteristics of the grain, which include its type, quality, grade, and moisture content, and the amount of entrained foreign material. Emission rates are also affected by the method of unloading and the size of the receiving hopper, the speed of transport on conveyors during the conveying process, the free fall distance between the loading spout and the receiving carrier during loading, and the degree of protection from winds during loading and unloading.

Regulations

NSPS. The NSPS for grain elevators (40 CFR 60.300) was promulgated August 3, 1978. It regulates both process and fugitive particulate emissions from truck, barge, and rail car loading and unloading stations, grain dryers, and all grain handling operations at grain terminal elevators and grain storage elevators located at feed mills. Exemptions include grain terminals with storage capacity less than 2.5 million bushels and grain storage elevators at grain mills with storage capacity less than 1.0 million bushels. Elevators at feed mills, discussed in Chapter A9.4, are not covered by this NSPS.

SIPs. Most states set general standards for particulate emissions from all types of process industries, although some states specifically address feed milling or grain processing. The emission standards are expressed in one of four measures: concentration in air volume, control efficiency, gas volume, and process weight rate. RACT standards suggested in Appendix B (40 CFR 51, App. B) are expressed as emission rate limits for process weight rates.

Control Technology

Particulate emissions from grain handling operations can be controlled either by eliminating emissions at the source or by collecting emissions. Techniques that eliminate dust emissions or that retain dust within the process include enclosed conveyors, covers on bins, tanks, and hoppers, and maintenance of the system's internal pressure below the external pressure so that airflow is inward rather than outward from the openings. Control methods that capture and collect the dust that is entrained or suspended in the air include cyclones and fabric filters. These dust collection systems require extensive hooding and aspiration systems.

In 1972, about 30 percent of country elevators, 40 percent of inland terminals, and 55 percent of port terminals had dust collection systems. Most of these were cyclones, although a few terminals used fabric filters. High efficiency cyclones provide sufficient control for country elevators to meet most SIPs. Terminals can comply with SIPs by installing cyclones on most loading operations and fabric filters on grain handling and unloading operations. New and modified larger country elevators and terminals must install fabric filters on all operations to comply with NSPS.

Costing Methodology

Table A9.3.1 presents a summary of grain elevator control costs. These total compliance costs for grain elevators were estimated with cost functions developed from control costs for model plants. There are separate functions for new and existing small country, large country, inland terminal, and port terminal elevators. Credit for the grain recovered with cyclones and fabric filters was estimated with credit functions derived from product recovery rates and an average grain price. Costs and credits are functions of million bushels of grain throughput per year.

Both costs and credits are based on data in the Environmental Impact Statement for the Grain Elevator NSPS (EPA 450/2-77-001a).

Table A9.3.1. Grain elevators

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .231E+09

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	344.32	85.43	85.43	178.06
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	24.24	97.64	70.43	148.02	319.68
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	24.24	441.96	155.86	233.45	497.74
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	56.50	169.85	163.90	333.40	560.90
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	22.10	41.99	56.83	143.31	381.36
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	78.60	211.84	220.73	476.71	942.26
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	-47.02	-143.12	-137.01	-276.64	-459.87
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	-16.63	-30.88	-42.64	-107.90	-288.89
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	-63.64	-174.00	-179.64	-384.54	-748.76
TOTAL ANNUAL COSTS	14.95	37.84	41.09	92.17	193.50

Chapter A9.4 Feed Mills

This chapter and Chapter A9.3, Grain Elevators, discuss the control of particulates from two stages of the feed and grain industry. The cost for feed mill compliance with SIPs is estimated in this chapter.

Industry Characteristics

Feed mills process grain, the primary raw material, and other constituents into finished livestock feed grains, including corn, oats, barley, and sorghum grains. Feed mills are distinct from grain mills, which process food grains such as wheat, rice, and rye. Feed mills receive grain either directly from farms or from country elevators and grain terminals, which are discussed in Chapter A9.3.

In 1975 there were about 7000 feed mills with a total production of 110 million tons per year. Almost 60 percent of mills and almost 40 percent of production are in the north central region of the country. This region includes the corn belt, the northern plains, and the lake states. Since 1969, the number of smaller mills (production less than 10 thousand tons per year) has declined relative to the number of larger mills (production greater than 25 thousand tons).

Feed mill production grew at an annual rate of 1.1 percent between 1969 and 1975 and increased to 2.5 percent between 1975 and 1981. Capacity utilization is estimated to have increased from about 80 percent in 1975 to an estimated 85 percent in 1981.

Feed mills are classified into SIC 2048, which covers the manufacturing of prepared feeds for animals and fowls by commercial mills. Mills operated by livestock and poultry producers are not included in this SIC code. According to the Census of Manufactures, this industry had 2000 commercial mills with a value of shipments of $8.8 billion in 1977. This implies that the remaining 5000 mills were operated by livestock and poultry producers.

Emission Sources and Pollutants

Feed milling involves the receiving, conditioning (drying, sizing, cleaning), grinding, mixing, and pelleting of the grains, and their subsequent bagging or bulk loading. The emissions from feed manufacture are particulates, especially dust.

The greatest source of emissions comes from unloading bulk ingredients from rail cars and trucks. The other major emission sources are the grinding and conveying operation and the pellet coolers. Factors affecting emissions include the type and amount of grain handled, the degree of drying, the amount of liquid blended into the feed, the type of conveying, and the configuration of the receiving pits (whether deep or shallow).

Regulations

Particulate emissions from feed mills are regulated primarily by SIPs. Although most states set general standards for particulate emissions from all types of process industries, some states specifically address feed milling or grain processing. The emission standards are expressed in one of four measures: concentration of air volume, control efficiency, gas volume, and process weight rate. RACT standards suggested in Appendix B (40 CFR 51, App. B) are expressed as particulate emission rate limits for various process weight rates. Most states pattern their SIPs after the Appendix B process weight rates.

No NSPS apply to feed mills. The NSPS for grain elevators (40 CFR 60.300) covers grain handling at grain mills but not at feed mills. Chapter A9.3 (Grain Elevators) discusses this NSPS.

Control Technology

Cyclones and fabric filters are the principal types of pollution control equipment used in feed mills. Cyclones are commonly installed on pellet coolers and grinding operations for product recovery and dust control. In 1972, cyclones were installed on pellet coolers in almost 90 percent of feed mills and on grinding operations in about 40 percent of feed mills. Fabric filters were installed on grinding operations in 15 percent of feed mills. About one third of the mills had installed either a cyclone or fabric filter on receiving and transferring operations.

We assume that cyclones are sufficient controls for plants existing in 1972 to comply with a typical SIP. Plants beginning operation after 1972, however, are expected to install fabric filters on all operations except pellet coolers to comply with SIPs. Plants existing in 1972 were assumed to be in full compliance by 1978. New plants are assumed to comply immediately.

Costs

Air pollution control costs are shown in Table A9.4.1. Compliance costs were estimated with cost functions derived from model plant cost data. Feed mills were divided into two categories of operation: processing and handling. Processing includes grinding and pellet coolers, and handling includes receiving, transferring, and shipping. Costs are a function of feed processing capacity measured in thousands of tons per year.

Cost functions for cyclones and fabric filters are based on data in the 1973 Midwest Research Institute grain and feed study (EPA 450/3-73-003a) and the Environmental Impact Statement for the grain elevator NSPS (EPA 450/2-77-001a). Neither the cost functions nor the resulting cost estimates for this chapter consider the value of products recovered by the air pollution control.

Table A9.4.1. Feed mills

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .505E+09

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	0.0	526.79	0.0	0.0	273.76
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	10.95	41.21	31.89	66.83	140.95
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	10.95	567.99	31.89	66.83	414.71
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	69.26	250.37	207.78	415.55	687.71
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	9.61	14.48	24.55	62.48	169.90
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	78.87	264.85	232.33	478.03	857.61
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	50.03	160.83	144.38	294.48	488.90
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	7.88	10.64	19.87	51.54	143.04
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	57.91	171.47	164.25	346.02	631.94
TOTAL ANNUAL COSTS	136.78	436.32	396.58	824.05	1489.55

Chapter A9.5 Plywood Veneer

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars, editing the discussion of industry characteristics, and revising the discussion of regulations..

Regulations

No NSPS governs this industry. Plywood veneer mills are subject to particulate and opacity regulations in SIPs.

Most general particulate and opacity standards in SIPs are taken from Appendix B (40 CFR 51). Oregon is the only state that has particulate matter and opacity regulations that apply specifically for plywood manufacture. The opacity regulations cover the condensable organic compounds from veneer dryers. The noncondensable organic compound emissions from veneer dryers are not regulated.

Industry Characteristics

It is reported that there are about 500 veneer and plywood mills in the U.S., 248 of which use softwood, 253 use hardwood, and 27 use a combination of softwood and hardwood. Hardwood plywood is distinguished from softwood plywood in that the former is generally used for decorative purposes and has a face ply of wood from deciduous or broad leaf trees. Softwood plywood is generally used for construction and structural purposes, and the veneers are of wood from coniferous or needle bearing trees. Hardwood and softwood mill locations are based on the availability of raw materials and product distribution patterns. The largest concentrations of mills are in Oregon, Washington, and North Carolina.

Pollutants and Sources

Emissions from the manufacturing of plywood include both particulates and organic compounds. Particulate matter results primarily from cutting and sanding operations. Veneer dryers emit condensable and non-condensable organic compounds. The condensable compounds form aerosols whose plume is regulated by opacity standards.

Control Technology

The control technology costed is incineration of organic compound emissions from the veneer dryers in a direct fired afterburner (with heat exchange).

Costing Methodology

Since there were no specific industry data available on either the applicable technology or costs of controlling the hydrocarbon emissions from the plywood veneer industry, the nation-wide cost impact was developed from the estimated costs of a 100 million square feet of plywood (3/8" basis) per year model plant and summarized in Table A9.5.1. The costs of controlling particulates were not considered because there were no data available and also because of their insignificant impact relative to the organic compound emissions control costs. The estimated costs presented in the table are based on the use of two sizes of model plants (representing hard- and softwood operations, each being an average size for that category) and the application of a cost function reflecting the use of gas-fired incineration (with heat recovery) of the volatile organic compounds in the gases from glueing and drying oven operations.

Table A9.5.1. Plywood veneer

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	2.05	2.43	4.89	11.80	19.14
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	2.05	2.43	4.89	11.80	19.14
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	1.19	0.78	2.60	8.38	24.49
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	1.19	0.78	2.60	8.38	24.49
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	0.47	0.28	1.01	3.39	10.59
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	0.47	0.28	1.01	3.39	10.59
TOTAL ANNUAL COSTS	1.66	1.06	3.60	11.77	35.08

Chapter A10. Solid Waste Reduction Industries

Except for ocean dumping (which is no longer widely practiced), the only ultimate disposal for solid wastes is on the land, either in sanitary landfills or in open dumps. Frequently, however, the volume of solid waste is reduced by burning, shredding, or composting prior to final disposal in order to conserve available land disposal areas.

Solid waste reduction contributes to air pollution through incineration, with or without heat recovery, and by open burning. Air pollutants emitted to the atmosphere from these practices include particulates, carbon monoxide, sulfur oxides, nitrogen oxides, hydrocarbons, fluorocarbons, hydrochloric acid, and odors. The levels of pollutants emitted are primarily dependent upon the particular waste being burned. Incinerator emission levels are also dependent upon the incinerator design and upon the method of operation.

Particulate emissions are the greatest, making them the specific pollutant subject to controls. There are no current Federal regulations for odors, hydrochloric acid, or fluorocarbons. Besides air-pollution laws, federal and state solid waste management regulations have had an effect on air pollution by reducing open dumps, and thereby reducing open burning. The relative effect of air-pollution laws versus solid waste regulatory laws has not been determined.

The costs for control of air pollution from municipal and industrial incineration operations are shown in summary form in Table A10-1. These costs represent the application of various control devices to the different types of incinerators. Details of each category and the associated costs are given in Chapter A10.1, Municipal Waste, and A10.2, Industrial, Commercial, and Building Incinerators.

TABLE A10. SOLID WASTE REDUCTION
INDUSTRIES AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A10. 1	MUNICIPAL WASTE INCINERATION	5.32	71.02	38.63	58.58	57.10
A10. 2	INDUSTRIAL & BUILDING INCINERATORS	92.83	281.09	194.10	472.58	578.08
	TOTAL INVESTMENT	98.15	352.11	232.73	531.16	635.19

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
A10. 1	MUNICIPAL WASTE INCINERATION	25.62	51.21	79.29	155.17	250.13
A10. 2	INDUSTRIAL & BUILDING INCINERATORS	156.97	313.08	392.59	1048.09	2488.41
	TOTAL ANNUAL COSTS	182.58	364.30	471.88	1203.26	2738.53

Chapter A10.1 Municipal Waste

This chapter covers three aspects of municipal waste reduction: land disposal, traditional incineration, and the newer practice of refuse incineration in steam-generating (water-wall) incinerators. The incineration of sewage sludge is not considered here as it is included in the consideration of Municipal Water Pollution Control in the companion report. Revision of this chapter was limited to updating the cost estimates in the tables to 1981 dollars, making minor changes in the discussions of regulations and industry characteristics for municipal incineration, and expanding the discussion of regulations for refuse-fired steam generators.

Land Disposal

Burning in open dumps has been a source of smoke and other emissions in past decades. Because of this, dumps are discussed here in terms of regulations and control measures. However, the concept of the costs of control is complex, because of the difficulty in determining either the control approach provoked by the prohibition of open burning, or the fraction of the cost of the control measure attributable to the Clean Air Act. Previously, the approach to costing the control of burning at open dumps was to cost the conversion to sanitary landfills. However, it is judged that such conversions are not totally due to the Clean Air Act but should be allocated to regulations dealing with public health and waste disposal. The cost of conversion of open dumps to sanitary landfills for the period 1970 to 1990 has been estimated to involve a capital investment on the order of $5 billion and cumulative total annual costs on the order of $20 billion (both amounts over the twenty-year period). These estimated costs are not reported here as stated above, although the Clean Air Act has, by prohibition of open burning, contributed to the elimination of open dumps.

Regulations. While some state and local air pollution control agencies had established regulations limiting open burning before the 1970 Clean Air Act, the State Implementation Plans required by the Act universally included prohibitions on open burning (40 CFR Part 51). Some types of open burning may still be conducted or may be allowed if a permit is issued. These include burning in support of crop management, forest management, petroleum exploration and the flaring of waste gases. The practice of open burning for reduction of waste volume and for metal salvage is generally prohibited throughout the country.

Industry Characteristics. Open burning refers to the unconfined burning of any kind of material or waste, such as leaves, agricultural waste, domestic waste, etc. Open burning may be intentional, as in the case of many open burning dumps, agricultural waste burning, leaf burning, training fires, etc. It may also be accidental, as in the case of forest fires, coal-refuse fires, structural fires, etc.

Pollutants and Sources. Emissions from open burning reflect the composition of the material burned (volume of paper, plastic, wood, rubber, etc.), and its physical state (degree of compaction, moisture content, particulates, carbon monoxide, and hydrocarbons).

Control Technology. There is no control technology that can be applied to open burning in general. Many common uses of open burning, such as burning for silvicultural, agricultural, range, and wildlife management; training fires for firefighters; and heating for outdoor workers, are allowed only under limited conditions of weather, time, and location. Other frequent sources of open burning, such as forest fires and coal-refuse pile fires, are accidental, and are extinguished as soon as possible. The only suitable emission control for open dumps is to substitute the use of sanitary landfills. For the purposes of this report, it was assumed that the waste currently going to open dumps would be diverted to sanitary landfills.

Municipal Incineration

Regulations. New Source Performance Standards for particulate emissions from incinerators with charging capacities greater than 45.36 metric tons (50 short tons) per day were first promulgated on December 21, 1971 (36 FR 24876). Revisions were made in 1974 (39 FR 20790) and 1977 (42 FR 37936 and 41424). The NSPS require particulate emissions to be controlled to 0.18 grams/dry standard cubic meter (0.08 grains/dry standard cubic foot) corrected to 12 percent CO_2.

States preparing their SIP's in 1971 were provided with a RACT for particulate emissions from incinerators (Appendix B of 40 CFR, Part 51). At the time it was promulgated, the RACT stated that the emission of particulate matter from any incinerator could be limited to grams per kilogram (0.2 pounds/100 pounds) of refuse charged.

Many states have specific emission regulations for large incinerators. For existing units the particulate emission standards range from 0.1 to 0.3 grains per dry standard cubic foot, although some states have required that existing incinerators achieve the NSPS.

Industry Characteristics. There are two basic types of municipal incinerators. The refractory-lined furnace is the most common type in this country; the other type is the water-wall, or waste-heat recovery type, more common in Europe.

Conventional refractory-lined incinerators are usually continuously fed, large rectangular chambers. The amount of air supplied to the combustion chamber is greatly in excess of the amount theoretically needed for combustion. The excess air serves as a cooling medium, but it also causes turbulence and entrains large amounts of particular matter. The air pollution control equipment must be large enough to handle the great volumes of air and particulates. With strict air pollution control requirements, it has become very costly to build adequate air pollution control systems for these incinerators. The result has been the substantial decrease in the popularity of the refractory-lined incinerator noted above.

Since 1920, 322 municipal-scale incinerators have been built, and 42 modifications have been made to increase the capacity of these facilities. By 1972, however, there were only 193 incinerator plants in operation. The number of facilities decreased to 145 in 1974 and 103 in 1977.

Pollutants and Sources. Municipal incinerators contribute to air pollution by releasing a variety of pollutants, but primarily particulates, to the atmosphere. The levels of these pollutant emissions are directly related to the design and operation of the incinerator, as well as to the composition of the refuse burned. Particulate limitations generally range from 80 to 200 grams of particulate per 100 kg (0.08 to 0.2 pounds per 100 pounds) of refuse charged.

Control Technologies. Electrostatic precipitators and wet scrubbers are used to control particulates. Most commonly, however, incinerators are closing, rather than upgrading facilities to meet air regulations. Thirty-nine percent (39%) of the operating incinerators closed from 1969 to 1974.

The Costing Methodology. An estimated population of traditional municipal incinerators was developed and the costs for application of electrostatic precipitators applied to this sector of operations. As noted above, this category of incinerator was considered to decline in numbers and be replaced by either more modern incinerators discussed below or by alternative waste disposal such as sanitary landfill.

Refuse-Fired Steam Generators

Regulations. NSPS for non-fossil fuel fired boilers are under development. These standards will include particulate emission limits for municipal solid waste and refuse-derived fuels. Refuse-fired steam generators are now governed by SIP regulations established for fuel-burning installations. The particulate, sulfur dioxide, and nitrogen oxides standards for refuse-fired generators are generally less stringent than those for fossil fuel fired boilers.

Industry Characteristics. Domestic, commercial, and industrial solid wastes contain large quantities of combustible material which can be used as fuel in a steam generator. In some cases, refuse may be the only fuel or refuse may be supplemental to fossil fuels. Both cases are covered in this section. Other waste-to-energy techniques, such as pyrolysis and small modular incinerators which recover energy in the form of hot water, are not covered.

The amount of recoverable, dry, combustible material in various wastes is shown in Table A10.1.1.

Table A10.1.1. Recoverable, dry combustible material in various wastes

Waste stream	Early 70's		1980		1990	
	Million metric tons	Million short tons	Million metric tons	Million short tons	Million metric tons	Million short tons
Municipal Solid Waste	61.1	67.4	78.0	86.0	98.0	108.0
Sewage Sludge	11.5	12.7	14.0	15.4	16.5	18.2
Industrial Waste	42.3	46.6	48.2	53.1	49.9	55.0
Agircultural Waste	210.2	231.7	316.2	348.5	384.6	424.0
Total	325.1	358.4	456.4	503.0	549.0	605.2

It is estimated that solid wastes from the largest metropolitan areas in the U.S. could be converted to supply a small but significant percentage of the nation's energy needs.

Two principal technologies are used for refuse-fired steam generators. One is production of steam in a water-wall incinerator, burning refuse (with or without prior shredding and classification) on moving grates. The other technology is the preparation of refuse-derived fuel (RDF), which involves shredding, followed by separation of the wastes into the light organic (fuel) fraction, and the heavy, principally inorganic, fraction which may undergo additional processing for recovery of metals and glass. The RDF is generally suspension-fired in a utility-type boiler, often as a supplement to fossil fuel.

As of October, 1979, four refuse-fired water-wall incinerators and five RDF-fired boilers were known to be in operation. At lease four other RDF-fired systems appeared to be close to operation. Three other facilities were producing RDF fuel, which was being evaluated as boiler fuel. It has been estimated that 30-40 such facilities will be committed by 1982.

Pollutants and Sources. Refuse-fired steam generators emit principally particulates, sulfur oxides, and nitrogen oxides. Uncontrolled emissions from coal-fired utility boilers and for municipal incinerators are shown in Table 10.1.2.

Control Technologies. Electrostatic precipitators are capable of meeting the particulate standards for existing sources. Most utility boilers burning supplemental RDF will be equipped with ESP's. The proposed regulations for new sources will necessitate the installation of fabric filters. Sulfur oxides are not expected to occur in excess of standards due to the low sulfur content of solid waste. Nitrogen oxides emissions are controlled by maintaining the furnace temperature within a range in which nitrogen oxides do not form in significant amounts.

The Costing Methodology. Costs were estimated empirically. Costs for pollution control for a typical water-wall incinerator and for a typical utility boiler burning supplemental RDF are as shown in Table A10.1.3.

Total estimated costs for the control of emissions from municipal incinerators are shown in Table A10.1.4. These estimated costs include both the declining numbers of traditional incinerators and the increasing numbers of steam-generating incinerators.

Table 10.1.2. Uncontrolled emissions factors from coal-fired utility boilers, and from incinerators (in kg per metric ton feed with lb per short ton feed in parentheses)

	Particulates 2/	Sulfur Oxides 3/	Nitrogen Oxides
Pulverized bituminous coal-fired boilers 1/	[8(16)][A] 2/	[19(38)][S] 3/	9(18)
Municipal incinerators 4/	15 (30)	1.25 (2.5)	1.5 (3)

1/ For utility boilers with greater than 100 x 10^6 Btu/hour heat input.
2/ The constant A stands for the percent ash in the coal.
3/ The constant S stands for the percent sulfur in the coal.
4/ For municipal incinerators burning more than 50 tons/day of refuse.

Table A10.1.3. Pollution control costs for a typical utility boiler burning refuse-derived fuel (in 1977 dollars)

		Existing sources	New sources
Water-wall incinerator:	Investment	2,000,000	860,000
	O&M	14,000	98,000
RDF/Utility	Investment	2,000,000	950,000
	O&M	14,000	100,000

Table A10.1.4. Municipal waste

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .895E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	5.32	71.02	38.63	58.58	57.10
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	5.32	71.02	38.63	58.58	57.10
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	14.42	28.81	41.15	89.65	174.56
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	14.42	28.81	41.15	89.65	174.56
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	11.20	22.41	38.14	65.53	75.57
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	11.20	22.41	38.14	65.53	75.57
TOTAL ANNUAL COSTS	25.62	51.21	79.29	155.17	250.13

Chapter A10.2 Industrial, Commercial, and Building Incinerators

Revision of this chapter was limited to adjusting the pollution control costs to 1981 dollars and editing the discussion of regulations.

Regulations

The NSPS for incinerators, promulgated on December 23, 1971 (40 CFR 60.50) and revised in 1974, sets flue gas concentration limits for particulate emissions from incinerators with a charging rate greater than 50 tons per day. Control cost estimates for these large incinerators are developed in Chapter A10.1. This chapter presents costs only for intermediate-sized units.

Most SIPs have particulate standards for incinerators. These standards are expressed in a variety of forms: on a concentration basis or on the basis of process weight rate, gas volume, or control efficiency. The limits in many SIPs vary with the capacity size and age of the incinerator. Some states require that existing larger incinerators meet the NSPS standard. Appendix B suggest particulate standards achievable with RACT (40 CFR 51, App. B). Many of the state regulations are patterned after these limitations, which are based on the weight of refuse charged per hour.

Industry Characteristics

In 1972, approximately 100,000 on-site incinerators were in use in this country. These intermediate-sized units are usually associated with office buildings, large retail stores, and apartment buildings. Of the over 24 million metric tons (26 million short tons) of solid waste incinerated annually in the United States, more than one-third is processed by on-site units that typically process about 81 metric tons (89 short tons) annually, or approximately 103 kg (228 pounds) per hour. States bordering the Great Lakes (Minnesota, Ohio, Illinois, Wisconsin, Michigan, Indiana, New York, and Pennsylvania) account for about 60 percent of the total number of on-site units in the United States.

There are two types of commercial, building, and industrial incinerators: single-chamber and multiple-chamber. Single-chamber incinerators are similar to residential or domestic units and consist of a refractory-lined chamber with a grate on which the refuse is burned. Combustion products are formed by contact between under-fire air and waste on the grate. Additional air (over-fire air) is admitted above the burning waste to promote complete combustion. Multiple-chamber incinerators employ a second chamber to which combustion gases from the primary chamber are directed for further oxidation of combustible gases. Auxiliary burners are sometimes employed in the second chamber to increase the combustion temperature.

It is estimated that the use of apartment incinerators, which account for about 6 percent of installations for refuse disposal, will virtually disappear during the 1976-85 period. The number of industrial and commercial units should remain stable during that decade because new installations will primarily be replacements of older units.

Approximately 88 percent of all on-site incinerators are the multiple-chamber type; emissions from multiple-chamber incinerators are generally lower than from the single-chamber incinerators. The design capacity of the incinerator considered in this report is from 23 kg (50 pounds) per hour to 1,800 kg (4,000 pounds) per hour, and the average incinerator operates from 3 to 5 hours a day.

Pollutants and Sources

While on-site units emit various products of combustion, only particulates are released in sufficient quantities to warrant installation of controls. Approximate emission factors for single-chamber and multiple-chamber incinerators of intermediate size are respectively 7.5 and 3.5 kg per metric ton (15 and 7 pounds per short ton) of refuse charged.

Control Technology

Operating conditions (e.g., air supply to the combustion chamber), refuse composition, and basic incinerator design have a pronounced effect on the volume and composition of air emissions. Afterburners and wet scrubbers can be installed to control particulate emissions and some other combustion products. However, with the shortage and expense of natural gas and fuel oil, the use of afterburners as retrofit controls on building incinerators will probably be curtailed. Furthermore, the newer multiple-chamber units already employ auxiliary firing techniques which, in effect, fulfill the function of an afterburner.

Wet scrubbers will achieve approximately an 80 percent reduction in particulate emissions. This level of control is sufficient to meet federal particulate emission standards of 2 kg per metric ton (4 pounds per short ton) of refuse charged.

Costing Methodology

The unit investment cost for a wet scrubber required to control an intermediate size incinerator (approximately 82 metric tons or 90 short tons per year) is estimated to be $7,500. Annual operating and maintenance costs will be about $1,500 per installation.

Control costs are detailed in Table A10.2.1. No costs are shown in the "new plant" category due to the above-mentioned conditions of net decreasing use of such incinerators.

Table A10.2.1. Industrial, commercial, and buildng incinerators

AIR POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .976E+08

	1981	1970-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
SIP	92.83	278.49	194.10	472.58	578.08
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	92.83	278.49	194.10	472.58	578.08
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
SIP	62.13	123.16	155.33	414.96	984.14
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	62.13	123.16	155.33	414.96	984.14
ANNUAL O & M COSTS					
EXISTING PLANTS					
SIP	94.49	187.30	236.23	631.08	1501.76
REVISED SIP	0.0	0.0	0.0	0.0	0.0
NEW PLANTS					
NSPS	0.0	0.0	0.0	0.0	0.0
LAER/BACT	0.0	0.0	0.0	0.0	0.0
TOTAL	94.49	187.30	236.23	631.08	1501.76
TOTAL ANNUAL COSTS	156.63	310.45	391.56	1046.03	2485.90

THE COST OF CLEAN WATER

REPORT OF THE ADMINISTRATOR

OF THE

ENVIRONMENTAL PROTECTION AGENCY

TO THE

CONGRESS OF THE UNITED STATES

IN COMPLIANCE WITH

SECTION 516(b) OF PUBLIC LAW 92-500, THE FEDERAL WATER POLLUTION
CONTROL ACT AMENDMENTS OF 1972

W1-1

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Chapter W1 Introduction and Summary

The Cost of Clean Water Report is written to fulfill the requirements of the Federal Water Pollution Control Act Amendments (PL92-500, hereafter noted as FWPCA) of 1972. Section 516(b) of the amendments requires the completion of a detached summary of the costs of meeting the provisions of that Act.

This report, therefore, provides water pollution control cost estimates for each industry (or other source category) which incurs high control costs and/or produces high levels of uncontrolled emissions. The costs included in this report are those costs which are directly attributable to control measures (devices, process changes, etc.) and program costs for research, administration, and enforcement at the federal, state, and local levels. Sources of water pollution are broken down into industrial, municipal, and nonpoint source categories.

The costs included in this report are assessments of what will be required to meet existing technology and water quality standards and to provide for replacement and expansion of existing facilities and new facilities. They are not based on surveys of actual industry expenditures nor projected oulays by federal, state, and local governments to construct or operate wastewater treatment facilities or non-point source controls.

This report does not attempt to include all costs associated with the reduction of the pollution of the Nation's Waterways or costs of various state and local regulations which preceded federal water pollution control regulations. Thus the costs summarized in this document are restricted to incremental costs which are over and above any control costs incurred on the level of control practiced prior to the FWPCA. Incremental costs were calculated using 1972 as the baseline year. The estimated direct cost of measures to control water pollution from industrial and other sources are calculated within this framework, and investment costs are projected through 1990. All abatement costs in this report are stated in January 1981 dollars. Where costs are derived relative to another time period, these costs were updated using the Implicit Price Deflater of the Gross National Product (Fixed nonresidential investment part).

Estimates of the capital investment and annualized costs required for implementing the FWPCA in the year 1981 and 1972-78, 1979-81, 1979-84, and 1981-90 are summarized in Table W1.6. (Annualized costs include operating and maintenance costs, depreciation of investments, and interest charges.) Each number in Table W1.6 is repeated within the appropriate chapter of this report where specific assumptions and background data are presented and discussed.

The chapter corresponding to each industry is divided into five sections: Regulations, Industry Characteristics, Pollutants and Sources, Control Technology, and Cost Methodology. Appendices for each of the individual chapters are grouped together in a separate volume. The appendices contain more detailed cost information, descriptions of regulations, industry data, assumptions, and references. A comprehensive reference list also appears at the end of this volume. The purpose of this report is to estimate and summarize water pollution control costs for a very broad range of industries. The report is not intended to provide detailed discussions of production processes and the complete range of applicable control techniques.. Interested readers are encouraged to consult the references for more complete technical descriptions and evaluations.

Note that this report specifically does not dictate EPA policy with respect to the application of presently available or projected technology for the control of effluent quality by an industry or activity. Simplifying assumptions were required in order to estimate the effect of EPA Regulations on the industries included. The control technologies, or mix thereof, which were assumed in order to provide these estimates are neither specifically required by law nor by EPA; no contrary interpretation of the contents of this document should be made.

The remainder of this introduction is presented in two sections. The first section provides an overview of federal water pollution control requirements and regulations. The second section describes the methodology used in this report to estimate water pollution control costs. These discussions are presented in this introduction to avoid excessive repetition within the main body of the report. A thorough reading of these sections will enhance the reader's understanding of the individual chapters.

Federal Water Regulations

EPA promulgates regulations limiting the discharge of pollutants under Sections 301, 304, 306, 307, and 501 of the FWPCA as amended by the Clean Water Act of 1977, Pub. L. 95-217 (The "Act"). The Act requires the Agency to promulgate water pollution control limitations for industries discharging to the Nation's waters. The promulgation of these limitations was intended to occur in phases, beginning with limitations based on the best practicable control technology currently available (BPT) and later advancing to the best available technology economically achievable (BAT). Limitations must also be considered for conventional pollutants such as biochemical oxygen demand based on the best conventional pollutant control technology (BCT). New sources are to be regulated under new source performance standards (NSPS). The Act also requires the Agency to promulgate regulations limiting the discharge of pollutants by industry to publicly owned treatment works (POTW). These limitations are known as pretreatment standards for existing sources (PSES) and pretreatment standards for new sources (PSNS).

In 1976, EPA was sued by several environmental groups for failure to promulgate toxic pollutant regulations within the time periods specified in the Act. This lawsuit resulted in a Settlement Agreement (also known as the NRDC Consent Decree) which sets forth a timetable for promulgation of regulations controlling the discharge of 65 toxic pollutants and classes of toxic pollutants from 21 major industries. It also sets forth, in paragraph 8, bases for an Agency decision not to promulgate regulations for the various industries or pollutants. The permissible bases for exclusion are listed in Table W1.1. A list of industries excluded is included in Table W1.2. The effect of these exemptions is included in this report.

Management, technical, and legal difficulties precluded EPA from incorporating the effects of all of the regulatory changes related to the NRDC Consent Decree and the Clean Water Act. In making a decision whether to revise estimates of an industry's pollution control costs, EPA considered the industry's contribution to total pollution control costs and the availability of supporting documents. The "report status", Table W1.3 provides a summary of the regulatory changes incorporated in the cost estimates included in this report for the NRDC industries.

Application of the best available technology economically achievable (BAT) must be attained by July 1, 1984, for toxic pollutants. BAT must be achieved for nonconventional and non-toxic pollutants within three years of their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987. EPA issued regulations for BAT for some industries before the NRDC Consent Decree. Some of these regulations were directed at conventional pollutants, others at toxic pollutants. These BAT regulations are referred to in the individual chapters as "BAT (old)". Application of the best conventional pollutant control technology (BCT) must be attained by July 1, 1984.

Cost Methodology

Cost estimates for each industry are presented in a table following the corresponding chapter text. To estimate compliance costs the industry is usually divided into a number of sectors. Sectors are defined according to production process, control technology, regulations, available cost data, or any other factors that can influence costs. The cost data for an individual sector may take one of two forms: "exogenous" total costs, or cost functions. The cost methodology section in each chapter indicates the type of cost data used in that chapter.

Exogenous costs are calculated outside the computer model for the report. The exogenous form is sometimes used because the complexity of the chapter precludes the use of cost functions alone. In other instances, these costs are taken from a detailed economic study of the industry commissioned by the EPA. The use of these studies improves the consistency and coherency of this report with other EPA publications. Some of these economic reports may not provide detailed information about control costs. In these cases the reported costs do not necessarily conform to the standard format, e.g., new plant costs may not be separately identified, although costs projected into the future include costs for both new and

Table W1.1. Permissible bases for exclusion of toxic pollutants and industry subcategories from regulation 1/

- equal or more stringent protection is already provided by the Agency's guidelines, limitations, and standards under the Act [8(a)(1)];

- except for pretreatment standards, a specific pollutant is present in the effluent discharge solely as a result of its presence in intake waters taken from the same body of water into which it is discharged; [8(a)(ii)];

- for pretreatment standards, the specific pollutant is present in the effluent which is introduced into a POTW solely as a result of its presence in the point source's intake water [8(a)(ii)];

- a pollutant is not detectable with the use of analytical methods approved pursuant to 304(h) of the Act, or where approved methods do not exist, with the use of state-of-the-art analytical methods [8(a)(iii)];

- a pollutant is detectable from only a small number of sources within a subcategory and the pollutant is uniquely related to those sources [8(a)(iii)];

- a pollutant is present only in trace amounts and is neither causing nor likely to cause toxic effects [8(a)(iii)];

- the pollutant is present in amounts too small to be effectively reduced by technologies known to Administrator [8(a)(iii)];

- the pollutant will be effectively controlled by the technologies upon which other effluent limitations and guidelines, standards or performance, or pretreatment standards are based [8(a)(iii)];

- the amount and toxicity of each pollutant in the discharge does not justify developing national regulations in accordance with the Settlement Agreement schedule [8(a)(iv)];

- for pretreatment standards, if 95 percent or more of the dischargers in the industrial category or subcategory discharge pollutants into publicly owned treatment works and the pollutants are susceptible to treatment by such treatment works and do not interfere with, do not pass through, or are not otherwise incompatible with the treatment works [8(b)(i)];

Continued....

Table W1.1. (Continued

- for pretreatment standards, if the amount and toxicity of incompatible pollutants discharged to publicly owned treatment works is so insignificant as not to justify developing pretreatment standards in accordance with the schedules in the Agreement [8(b)(ii)].

1/ Paragraph 8 of the NRDC consent decree.

Table W1.2. Industires excluded from further regulation under provisions of paragraph 8 in the NRDC Consent Decree (modified 1979)

Industrial category	CFR part number
Adhesives and sealants	456
Auto and other laundries	444
Carbon black	458
Explosives manufacturing	457
Gum and wood	454
Ink formulation	447
Paint formulation	446
Paving and rocfing	443
Photographic equipment and supplies	459
Printing and publishing	448
Rubber processing	428
Soaps and detergents manufacturing 1/	417

1/ Exclusion only from those SIC's addressed in the Consent Decree.

Table W1.3. Consideration of recent regulatory changes by the Cost of Clean Water Report

Industry	40 CFR part	Type rule	Signature 1/	Federal register citation		Report status 2/
Aluminum Forming	467	Proposal Promulgation	11/ 5/82 9/83	47 FR 52626 ---	11/22/82 ---	---
Battery Manufacturing	461	Proposal Promulgation	10/29/82 1/84	47 FR 51052 ---	11/10/82 ---	---
Coal Mining	434	Proposal Promulgation	12/30/81 9/30/82	46 FR 3136 47 FR 45382	01/13/81 10/13/82	No
Coil Coating Phase I	465	Proposal Promulgation	12/30/80 11/ 5/82	46 FR 2934 47 FR 54232	01/12/81 12/ 1/82	Yes
Phase II (Canmaking)	465	Proposal Promulgation	1/31/83 (10/83)	48 FR 6268 ---	02/10/83 ---	---
Copper Forming	468	Proposal Promulgation	10/29/82 (07/83)	47 FR 51278 ---	11/12/82 ---	---
Electrical/Electronic Components Phase I	.469	Proposal Promulgation	8/11/82 3/31/83	47 FR 37048 48 FR 15382	08/24/82 04/08/83	---
Phase II	469	Proposal Promulgation	2/28/83 (11/83)	48 FR 10012 ---	03/09/83 ---	---
Electroplating (Pretreatment)	413	Proposal Promulgation Proposed Amendment	1/24/78 8/ 9/79 8/11/82	43 FR 6560 44 FR 52590 47 FR 38462	02/14/78 09/07/79 08/31/82	 Yes Yes
Foundries (Metal Molding and Casting)	464	Proposal Promulgation	10/29/82 6/84	47 FR 51512 ---	11/15/82 ---	---
Inorganic Chemicals Phase I	415	Proposal Promulgation	7/10/80 6/16/82	45 FR 49450 47 FR 28260	07/24/80 06/29/82	Yes
Phase II	415	Proposal Promulgation	(09/83) (06/84)	--- ---	--- ---	---
Iron and Steel Manufacturing	420	Proposal Promulgation	12/24/80 5/18/82	46 FR 1858 47 FR 23258	01/07/81 05/27/82	Yes
Leather Tanning and Finishing	425	Proposal Promulgation	6/13/79 11/ 7/82	44 FR 38746 47 FR 52848	07/02/79 11/23/82	Yes

Continued...

Table W1.3. (Continued)

Industry	40 CFR part	Type rule	Signature 1/	Federal register citation		Report status 2/
Metal Finishing	433	Proposal	8/11/82	47 FR 38462	08/31/82	
	& 413	Promulgation	7/ 5/83	48 FR 32462	07/15/83	Yes
Nonferrous Metals Phase I	421	Proposal	1/31/83	48 FR 7032	02/17/83	No
		Promulgation	(01/84)	---	---	
Phase II	421	Proposal	2/84	---	---	---
		Promulgation	11/84	---	---	
Nonferrous Metals Forming	471	Proposal	1/84	---	---	---
		Promulgation	10/84	---	---	
Ore Mining	440	Proposal	5/25/82	47 FR 25682	06/14/82	
		Promulgation	11/05/82	47 FR 54598	12/ 3/82	No
Organic Chemicals and Plastics and Synthetic Fibers	414	Proposal	2/28/82	48 FR 11828	03/21/83	No
	& 416	Promulgation	(03/84)	--	--	
Pesticides	455	Proposal	11/05/82	47 FR 53994	11/30/82	No
		Proposal - (Analytical Methods)	1/31/83	48 FR 6250	02/10/83	
		Promulgation	(12/83)	---	---	
Petroleum Refining	419	Proposal	11/27/79	44 FR 75926	12/21/79	
		Promulgation	9/30/82	47 FR 46434	10/18/82	Yes
Pharmaceuticals	439	Proposal	11/07/82	47 FR 53584	11/26/82	Yes
		Promulgation	(09/83)	---	---	
Plastics Molding and Forming	463	Proposal	1/84	---	---	---
		Promulgation	9/84	---	---	
Porcelain Enameling	466	Proposal	1/19/81	46 FR 8860	01/27/81	
		Promulgation	11/ 5/82	47 FR 53172	11/24/82	Yes
Pulp and Paper	430	Proposal	12/11/80	46 FR 1430	01/06/81	
	& 431	Promulgation	10/29/82	47 FR 52006	11/18/82	Yes
		Proposal - (PCB's)	10/29/82	47 FR 52066	11/18/82	Yes
Steam-Electric	423	Proposal	10/ 3/80	45 FR 68328	10/14/80	Yes
		Promulgation	11/ 7/82	47 FR 52290	11/19/82	No

Continued...

Table W1.3. (Continued)

Industry	40 CFR part	Type rule	Signature 1/	Federal register citation		Report status 2/
Textile Mills	410	Proposal	10/16/79	44 FR 62204	10/29/79	
		Promulgation	8/27/82	47 FR 38810	09/02/82	Yes
Timber	429	Proposal	10/16/79	44 FR 62810	10/31/79	
		Promulgation	1/ 7/81	46 FR 8260	01/26/81	Yes

1/ Administrator's signature; ( ) is the projected schedule approved by the Court on August 25, 1982 and October 26, 1982; that has been requested by EPA (R. Hanmer Affidavit, June 21, 1983).

2/ "-" indicates the industry has not been included in this report, "Yes" indicates that the cost estimates included in the report incorporate this regulatory action, and "No" indicates that the cost estimates included in the report do not incorporate this regulatory action.

existing plants. Similarly, the source document may not use the same breakdown of annual costs or the same interest rate as is normally used in the existing computer model. Nevertheless, the overall costs and timing of the costs are reported as developed in the designated source document.

Costs in most chapter sectors are generated from cost equations that express control costs as a function of plant capacity. (Larger plants usually benefit from economies of scale.) In most cases future cost estimates are based on the assumption of continued application of current technologies. Capital and operating and maintenance costs are calculated separately. The computer program computes total industry costs by applying the cost functions to industry plant data, taking into account compliance schedules estimated by the chapter author. The cost functions, which are based on engineering model plant costs, are expressed in a standard exponential form: $\text{Cost} = AX^B$, where X is a measure of capacity. O&M costs are adjusted according to estimates of capacity utilization percentages. Industry plant data include the plant population for a base year, historical growth rates, and expected future growth rates. Compliance information is simply the percentage of the plant population that complied with a regulation in each past year and estimates of the percentage that will comply in each future year. These estimates are based on the compliance date specified in the pertinent regulation, allowing for lead time required to construct and install the control technology required. New plants are assumed to comply upon construction.

To calculate the annual cost of capital, the computer program uses the stated life of the control equipment and an interest rate of ten percent. It is understood that other systems of depreciation are used, that other interest rates are sometimes applicable, that "opportunity costs" for other uses of capital are not taken into account, and that tax write-offs are commonly applied to control equipment. The ten percent interest rate is used as a "compromise" value which is intended to reflect an average value of the highly varied individual cases.

The computer program also calculates the cost of replacing control equipment at the end of its useful life. These costs are assumed to be some fraction of the original cost of equipment as certain elements, such as the foundations, do not need to be replaced.

The program excludes costs associated with water pollution control that would have been incurred without the inducement of federal regulations. It does this by excluding from the plant population a precompliance fraction that is provided by the chapter author. This fraction represents plants that either can comply with the applicable regulation without installing controls or plants that installed controls even in the absence of regulations.

Wastewater treatment costs estimated in this report do not reflect any actions taken by industrial plants to decrease overall wastewater discharge after promulgation of regulations. Consequently, the cost estimates may be overstated. While it is beyond the scope of this report to account for this type of overestimate, data collected by the

Bureau of Census indicate that the amount of water which is discharged by industry is decreasing. This finding implies that industry may be instituting water conservation measures.

Tables W1.4 and W1.5 reveal wastewater discharge data collected by the Bureau of Census for 1973 and 1978. The intake and discharge status of the industry when the Clean Water Act was passed is represented by 1973 data, while the data which are representative of intake and discharge status after the issuance of BPT regulations and permits are shown for the year 1978.

Table W1.4 indicates that gross water intake and total water discharged declined from 1973 to 1978, by 14 percent and 17 percent respectively. The sources of wastewater by last use are shown on Table W1.5. This table indicates that only two source categories have experienced an increase in water discharge since 1973.

The data collected by the Bureau of Census imply that BPT costs may be overstated due to decreases in the discharge of contact cooling water (water that comes into direct contact with raw material, intermediate product, waste product or finished product), which EPA regulations generally control. However, the amount of the potential overstatement of costs is unknown, since the data collected by the Bureau of Census does not delineate between contact and non-contact cooling water.

The cost methodology differs from that followed in the August, 1979 report in that it:

(1) includes estimates of replacement costs,

(2) does not assume that any fraction of industry was controlling emissions to the level set by New Source Performance Standards before the promulgation of these standards.

Table W1.4. Wastewater intake and discharge summary

	1973	1978	% Change
Establishments Reporting Water Intake of 20 Million Gallons	10,668	9,605	-10
Gross Water Intake (Billion Gallons)	15,024	12,992	-14
Gross Water Intake Per Establishment (Billion Gallons)	1.41	1.35	-4
Total Water Discharged (Billion Gallons)	14,144	11,682	-17
Water Discharged Per Establishment (Billion Gallons)	1.33	1.22	-8
Treated Wastewater Discharged (Billion Gallons)	6,156	4,709	-8
Untreated Wastewater Discharged (Billion Gallons)	7,987	6,973	-13

Source: U.S. Department of Commerce, Bureau of the Census, "1977 Census of Manufactures; Water Use in Manufacturing." MC77-SR-8 (August 1981).

Table W1.5. Summary of water discharged by last use
1973 and 1978
(Billion gallons)

	Water discharged	Process	Cooling & condensing	Sanitary	Boiler feed & other
Treated					
1973	6,156	2,790	3,116	53	197
1978	4,709	2,477	1,788	58	388
Difference	-1,447	-313	-1,328	+5	+191
Untreated					
1973	7,987	1,199	6,419	147	220
1978	6,973	1,019	5,439	205	311
Difference	-1,014	-180	-980	+58	+91
TOTAL					
1973	14,144	3,989	9,535	200	417
1978	11,682	3,496	7,227	263	699
Difference	-2,462	-493	-2,308	+63	+282

Source: U.S. Department of Commerce, Bureau of the Census, "1977 Census of Manufacturing; Water Use in Manufactures." MC77-SR-8 (August 1981).

TABLE W1.6 GOVERNMENT
WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

CHAPTER	INDUSTRY	1981	1970-78	1979-81	1979-84	1981-90
				INVESTMENT		
W 2.	GOVERNMENT EXPENDITURES	6539.00	53350.98	23820.99	41628.98	59962.96
				ANNUAL COSTS		
W 2.	GOVERNMENT EXPENDITURES	15519.12	52872.37	42963.12	95401.05	191748.23

Table W1.6 ENERGY
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 3. 1	COAL MINING	5.77	74.88	17.44	28.76	77.05
W 3. 2	OIL & GAS EXTRACTION	0.0	1290.90	0.0	0.0	71.56
W 3. 3	PETROLEUM REFINING	106.66	3150.38	264.00	535.03	377.69
W 3. 4	POWER PLANTS	17.08	599.26	28.47	113.90	166.98
	TOTAL INVESTMENT	129.52	5115.42	309.91	677.68	693.27

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 3. 1	COAL MINING	85.92	224.72	238.21	523.31	1010.89
W 3. 2	OIL & GAS EXTRACTION	570.97	1310.68	1683.23	3462.36	6185.62
W 3. 3	PETROLEUM REFINING	983.83	3088.64	2659.16	5850.52	10304.06
W 3. 4	POWER PLANTS	307.58	1331.42	901.95	1899.18	3452.85
	TOTAL ANNUAL COSTS	1948.30	5955.45	5482.53	11735.38	20953.41

Table W1.6 CHEMICAL INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 4. 1	ORGANIC CHEM.	254.23	3049.80	800.85	1801.18	5021.27
W 4. 2	INORGANIC CHEMICALS	8.76	224.44	13.30	34.41	137.18
W 4. 3	PLASTICS & SYNTHETICS	105.97	531.92	282.69	722.62	2914.31
W 4. 4	RUBBER MFG.	7.96	214.72	13.14	38.03	160.80
W 4. 5	SOAPS & DETERGENTS	0.34	5.38	0.97	2.59	5.20
W 4. 6	CARBON BLACK	0.50	0.93	1.50	3.85	3.32
W 4. 7	EXPLOSIVES	0.0	1201.81	0.0	0.0	0.0
W 4. 8	PESTICIDES	0.0	37.63	0.0	0.0	0.0
W 4. 9	FERTILIZER MFG.	46.68	208.50	135.72	239.59	403.58
W 4.10	PHOSPHATE MFG.	10.43	71.94	22.76	42.37	54.57
W 4.11	PAINT FORMULATING	1.36	13.21	3.80	8.58	24.49
W 4.12	PRINTING INK FORMULATING	0.0	2.88	0.0	0.0	0.0
W 4.13	PHOTOGRAPHIC PROCESSING	0.0	3.72	0.0	0.27	4.95
W 4.14	TEXTILES	5.11	59.85	19.55	45.97	122.12
	TOTAL INVESTMENT	441.33	5626.73	1294.28	2939.46	8851.77

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 4. 1	ORGANIC CHEM.	759.96	1416.26	2128.12	4779.76	11133.57
W 4. 2	INORGANIC CHEMICALS	91.43	273.25	262.67	558.85	1033.25
W 4. 3	PLASTICS & SYNTHETICS	150.40	277.47	393.02	1001.44	3318.03
W 4. 4	RUBBER MFG.	54.27	163.99	156.79	335.24	671.37
W 4. 5	SOAPS & DETERGENTS	1.23	2.33	3.51	7.82	16.76
W 4. 6	CARBON BLACK	0.40	0.23	0.96	3.13	7.62
W 4. 7	EXPLOSIVES	236.05	711.88	708.14	1416.29	2298.92
W 4. 8	PESTICIDES	9.52	28.76	28.57	57.14	93.31
W 4. 9	FERTILIZER MFG.	153.44	252.59	403.28	961.02	2251.55
W 4.10	PHOSPHATE MFG.	27.02	44.50	70.98	171.29	383.62
W 4.11	PAINT FORMULATING	4.13	10.48	11.42	26.06	61.05
W 4.12	PRINTING INK FORMULATING	0.51	2.22	1.52	3.04	4.39
W 4.13	PHOTOGRAPHIC PROCESSING	1.82	4.90	5.31	11.08	21.22
W 4.14	TEXTILES	26.72	60.17	74.49	167.36	355.10
	TOTAL ANNUAL COSTS	1516.89	3249.00	4248.78	9499.52	21649.75

Table W1.6 METALS
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 5. 1	ORE MINING & DRESSING	0.0	455.30	212.61	212.61	0.0
W 5. 2	IRON & STEEL	134.26	1537.91	461.13	937.30	896.48
W 5. 3	FERROALLOYS	1.32	28.69	1.83	5.13	6.14
W 5. 4	BAUXITE REF.	0.0	98.14	0.0	0.0	0.0
W 5. 5	PRIMARY ALUM.	8.57	49.97	26.20	34.77	28.94
W 5. 6	SECONDARY ALUMINUM	1.59	9.56	4.66	9.51	26.10
W 5. 7	ELECTROPLATING	0.0	0.0	0.0	662.33	785.27
W 5. 8	COIL COATING	4.38	0.0	11.11	25.33	32.70
W 5. 9	PORCELAIN ENAMELING	0.09	0.0	6.77	23.75	17.07
	TOTAL INVESTMENT	150.20	2179.57	724.32	1910.73	1792.71

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 5. 1	ORE MINING & DRESSING	165.68	221.95	486.76	983.80	1656.81
W 5. 2	IRON & STEEL	383.51	947.67	1025.06	2404.08	4891.98
W 5. 3	FERROALLOYS	12.42	34.67	36.88	78.16	140.40
W 5. 4	BAUXITE REF.	23.51	82.28	70.52	141.04	225.40
W 5. 5	PRIMARY ALUM.	29.31	53.91	77.74	175.64	376.70
W 5. 6	SECONDARY ALUMINUM	7.33	12.87	19.15	46.07	122.01
W 5. 7	ELECTROPLATING	0.0	0.0	0.0	216.33	910.12
W 5. 8	COIL COATING	3.63	0.0	6.27	25.17	80.12
W 5. 9	PORCELAIN ENAMELING	3.01	0.0	5.99	28.94	85.82
	TOTAL ANNUAL COSTS	628.39	1353.34	1728.36	4099.24	8489.33

Table W1.6 MINERAL-BASED INDUSTRIES WATER POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 6. 1	MINERAL MINING	1.20	11.70	1.65	5.43	13.43
W 6. 2	GLASS MFG.	3.49	14.73	17.40	22.76	19.37
W 6. 3	INSULATION FIBERGLASS	2.35	16.07	6.53	14.75	37.81
W 6. 4	ASBESTOS	0.87	2.55	2.60	4.03	4.81
W 6. 5	CEMENT MFG.	4.26	37.57	12.17	23.12	63.39
W 6. 6	PAVING & ROOFING	1.84	7.28	4.87	9.35	12.66
	TOTAL INVESTMENT	14.00	89.90	45.21	79.44	151.47

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 6. 1	MINERAL MINING	2.14	3.55	6.08	13.57	29.83
W 6. 2	GLASS MFG.	12.07	10.79	33.59	72.85	136.22
W 6. 3	INSULATION FIBERGLASS	6.82	14.17	18.38	43.66	110.75
W 6. 4	ASBESTOS	2.18	3.43	5.49	13.58	31.19
W 6. 5	CEMENT MFG.	12.31	29.47	34.04	76.69	170.83
W 6. 6	PAVING & ROOFING	11.00	20.60	30.03	68.78	144.97
	TOTAL ANNUAL COSTS	46.53	82.01	127.61	289.13	623.79

Table W1.6 FOREST PRODUCTS INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

CHAPTER	INDUSTRY	INVESTMENT 1981	 1972-78	 1979-81	 1979-84	 1981-90
W 7. 1	TIMBER PROD.	2.60	264.21	9.89	19.59	24.55
W 7. 2	FURNITURE MFG.	0.0	29.01	0.0	0.0	0.22
W 7. 3	GUM & WOOD CHEMICALS	2.90	43.51	7.11	13.78	42.23
W 7. 4	PULP & PAPER	8.01	3214.10	8.01	36.02	194.41
	TOTAL INVESTMENT	13.50	3550.84	25.00	69.39	261.41

CHAPTER	INDUSTRY	ANNUAL COSTS 1981	 1972-78	 1979-81	 1979-84	 1981-90
W 7. 1	TIMBER PROD.	56.56	180.29	166.39	340.62	574.75
W 7. 2	FURNITURE MFG.	7.02	26.49	21.06	42.13	70.39
W 7. 3	GUM & WOOD CHEMICALS	9.97	34.13	28.01	61.95	115.87
W 7. 4	PULP & PAPER	810.26	2582.40	2427.31	4868.21	8095.56
	TOTAL ANNUAL COSTS	883.81	2823.31	2642.77	5312.90	8856.57

Table W1.6 FOOD & AGRICULTURAL INDUSTRIES WATER POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 8. 1	GRAIN MILLS	2.41	14.25	6.94	14.82	33.49
W 8. 2	SUGAR PROCESSING	16.66	47.63	43.62	80.09	99.55
W 8. 3	FRUITS & VEGETABLES	4.21	881.16	12.22	22.60	270.06
W 8. 4	CANNED & PRESERVED SEAFOOD	5.35	62.56	15.72	27.56	49.66
W 8. 5	DAIRY PRODUCTS	11.64	243.91	33.35	70.02	214.87
W 8. 6	FEEDLOTS	7.03	96.07	20.50	44.39	138.67
W 8. 7	MEAT PRODUCTS	86.09	107.92	254.47	397.91	499.81
W 8. 8	LEATHER TANNING	28.58	0.0	50.43	154.30	145.46
	TOTAL INVESTMENT	161.97	1453.51	437.26	811.69	1451.57

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 8. 1	GRAIN MILLS	5.01	10.04	13.33	32.08	80.31
W 8. 2	SUGAR PROCESSING	22.00	29.71	55.58	140.57	321.91
W 8. 3	FRUITS & VEGETABLES	1147.97	3650.08	3443.83	6888.09	11479.43
W 8. 4	CANNED & PRESERVED SEAFOOD	18.37	39.67	51.70	113.01	228.64
W 8. 5	DAIRY PRODUCTS	43.80	129.89	125.60	269.42	530.88
W 8. 6	FEEDLOTS	33.03	92.25	93.08	205.39	442.99
W 8. 7	MEAT PRODUCTS	148.61	133.20	341.92	924.58	2281.99
W 8. 8	LEATHER TANNING	11.80	0.0	18.49	113.52	350.23
	TOTAL ANNUAL COSTS	1430.59	4084.83	4143.53	8686.66	15716.37

Table W1.6 OTHER INDUSTRIES
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

INVESTMENT

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 9. 1	PHARMACEUTICAL MFG.	6.65	2.86	12.88	20.78	15.06
W 9. 2	HOSPITALS	43.39	293.07	121.63	271.47	702.54
	TOTAL INVESTMENT	50.05	295.93	134.52	292.25	717.60

ANNUAL COSTS

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 9. 1	PHARMACEUTICAL MFG.	5.69	2.94	10.40	36.13	82.87
W 9. 2	HOSPITALS	101.67	219.91	271.94	652.98	1667.99
	TOTAL ANNUAL COSTS	107.36	222.85	282.34	689.10	1750.86

Chapter W2 Government Expenditures for Water Pollution Control

Introduction

Government funds for water pollution control are spent for three major purposes:

- To conduct programs of monitoring, enforcement, technical assistance, grant assistance, and research,
- To abate pollution created at government-owned facilities, and
- To treat wastewater at municipal treatment facilities.

Generally, states have primary responsibility for monitoring and enforcement, with financial and other assistance provided by the federal government. Research is conducted primarily by the federal government, and treatment of municipal wastewater is the responsibility of local and state governments, with major financial assistance from the federal and state governments.

Federal and State Pollution Control Expenditures

Summary. Federal and state government expenditures for water pollution control are summarized in Table W2.1 for calendar years 1972 to 1990. Actual incremental expenditures, in 1981 dollars, are reported for 1972 through 1981. Projections are shown for 1982 through 1990. Federal pollution control expenditures are detailed for abatement, regulation and monitoring, and research and development. Federal expenditures include EPA program costs and expenditures by other federal agencies.

Definitions. Abatement is any direct action to reduce the emission of pollutants at federal installations. Regulation and monitoring is a governmental activity that is indirect in the sense that it ensures that others take action to reduce pollutant emissions. Regulation and monitoring includes monitoring point discharges, testing ambient levels of pollution, developing and reviewing standards, issuing permits, and enforcing existing standards. Research and development is conducted for the purpose of finding and demonstrating new and better pollution abatement techniques.

Federal Program Costs. Federal pollution control responsibilities, exercised primarily through the U.S. Environmental Protection Agency (EPA), encompass a broad range of authorities, particularly since enactment of the Federal Water Pollution Control Act Amendments of 1972 and 1977. Compliance is encouraged through grants and other types of assistance, and it is required through regulatory programs.

Assistance Programs. The EPA conducts several assistance programs, including grants for wastewater treatment facilities, grants for regional water quality planning program development, technical assistance, and manpower development.

The construction grants program for wastewater treatment facilities is by far the largest federal pollution control assistance program. The level of assistance under this program has gradually increased since the first permanent federal pollution control legislation was enacted in 1956. A variety of projects are eligible for funding, including treatment plants and interceptor sewers. Federal, state, and local government expenditures for wastewater treatment facilities are discussed in this chapter under Municipal Pollution Control Expenditures and are not included in the expenditures shown in Table W2.1.

The EPA also provides program grants to assist the state, interstate, and regional agencies in the expansion and improvement of a variety of activities essential to the control of water pollution. These activities include water quality planning and standards setting, surveillance, enforcement, issuance of permits, executive management, and administration of the construction grants program. The level of assistance varies from one activity to another, as well as from year to year.

Technical assistance is another program receiving major EPA attention. Many pollution problems are too complex for states, communities, and industries to handle alone. The EPA offers assistance in such cases by providing services ranging from technical advice and consultation to extensive, long-term field and laboratory studies. Within the limits of available resources, this assistance is provided on request, primarily to the states and municipalities.

Federal expenditures for assistance programs related to planning, technical assistance, and manpower development are included in the regulation and monitoring category in Table W2.1.

Regulatory Programs. To facilitate enforcement of the many new pollution control requirements, the Federal Water Pollution Control Act Amendments of 1972 and 1977 replaced former enforcement authorities with new authorities and provided a new regulatory scheme based largely on the imposition of specific requirements through a system of permits termed the National Pollutant Discharge Elimination System (NPDES). Permit conditions and other requirements of the Act are enforceable through EPA compliance orders and civil suits. Violators are subject to penalties. A state may assume this responsibility if it meets certain requirements, including the capability and authority to modify, suspend, or revoke a permit, and it has the powers and procedures necessary for criminal penalties, injunctive relief, and other enforcement mechanisms.

The Act also required federal agencies to comply with federal, state, interstate, and local pollution control and abatement requirements to the same extent as any person must comply. The EPA's role stems from the Act and is amplified in Executive Order 11752. This role also includes

Table W2.1. Federal and state government incremental water pollution control expenditures (historical and projected costs in millions of 1981 dollars)

	Federal Expenditures 1/					
Year	Abatement	Regulation and monitoring	Research and development	Federal total	State expenditures	Total
1972	137	154	66	357	215	572
1973	242	186	117	545	233	778
1974	325	228	132	685	220	905
1975	393	226	114	733	214	947
1976	355	213	118	686	275	961
1977	365	195	120	680	323	1,003
1978	383	230	129	742	292	1,034
1979	386	264	134	784	241	1,025
1980	279	340	99	718	232	950
1981	236	293	121	650	231	881
1982	236	293	121	650	231	881
1983	236	293	121	650	231	881
1984	236	293	121	650	231	881
1985	236	293	121	650	231	881
1986	236	293	121	650	231	881
1987	236	293	121	650	231	881
1988	236	293	121	650	231	881
1989	236	293	121	650	231	881
1990	236	293	121	650	231	881
Total	5,225	4,966	2,229	12,430	4,555	16,985

1/ Excludes construction grant costs which are included in the municipal cost section and state program grant costs which are included in the state totals.

Source: 1972-1981 data are from Rutledge, Gary L., "Pollution Abatement and Control Expenditures in Constant and Current Dollars, 1972-1981," Survey of Current Business, February 1983. Projection for 1982-1990 assume a continuation of the 1981 levels of expenditures. Historical costs for 1972-1981 and projected costs for 1982 were adjusted by inflation factors to obtain costs in 1981 dollars. For updated water pollution control expenditures, refer to the February 1984 Survey of Current Business, "Pollution Abatement and Control Expenditures, 1972-1982," by Gary L. Rutledge.

reviewing the compliance of federal facilities with applicable standards, providing guidance to the federal agencies for implementing provisions of the Order, coordinating the compliance actions of federal agencies with state and local agencies, and furnishing technical advice on waste treatment technology.

State Program Costs. Although the federal government has taken increasing responsibility in dealing with water pollution, the states continue to bear the major share of the responsibility. States inherently have broad powers to deal with water pollution, and these powers, together with delegated federal authorities, place the states in a strong position to regulate all sources of pollution. State powers and responsibilities under the Act are exercised through a broad range of activities, including:

- Preparation of an annual strategy and program report that describes the interim goals to be achieved during the year, the state resources to be assigned in meeting the goals, and the method of assigning resources.
- Development of basin water quality management plans, as required by Section 303(e) of the 1972 Act. These plans are designed to be the central management tools of the states in administering their water quality programs.
- Review of areawide waste treatment management plans called for by Section 208 and prepared by local agencies.
- Administration of the construction grants program, including the responsibility for assigning priorities to the projects eligible for federal financial assistance. It is intended that certain federal responsibilities, such as review of plans and specifications, be transferred to the states as they are able to assume them. Some states provide funds to assist communities in constructing waste treatment works. Primary responsibility for monitoring municipal treatment plants to see that they operate correctly also rests with the states.
- Planning and implemention of programs for control of nonpoint sources of pollution.
- Administration of the NPDES permit program. Some states have assumed, and others are in the process of assuming this responsibility. States that have assumed responsibility for this program have concurrently assumed extensive enforcement responsibilities associated with permit compliance.
- Shared responsibility, with the federal government, for enforcement.
- Establishment and implementation of water quality standards. Under the 1972 Act, such standards are extended to intrastate, as well as interstate, waters.

- Monitoring and surveillance functions to identify and assess existing and potential water pollution problems, and also to measure the effectiveness of the permit and construction grants program.

Municipal Pollution Control Expenditures

Introduction. The 1972 amendments to the Clean Water Act established technology objectives and water quality objectives for controlling pollution from municipal sources. The objectives were restated and clarified by the 1977 amendments to the Act. The technology objectives require that all publicly owned wastewater treatment works be upgraded to secondary treatment levels by 1977 and best practicable wastewater treatment levels by 1983. Currently, secondary treatment (85 percent removal of organic and suspended solids waste loads, with the plant effluent quality not to exceed 30 mg/1 for both BOD_5 and suspended solids, and pH between 6.0 and 9.0) is considered equivalent to best practicable treatment. In addition, publicly owned treatment works must control their waste discharge as necessary to meet water quality standards by 1983. These standards are based on achieving a level of water quality that will provide for the protection and propagation of fish, shellfish, and wildlife, and will provide for recreation in and on the water. This section reports the costs associated with meeting these dual objectives in Table W2.2, with the exception of those costs incurred in the treatment and control of stormwaters.

Defining and Measuring Need. The 1982 Needs Survey, a joint State/EPA activity, conducted in compliance with Sections 205(a) and 516(b)(2) of the Act, requested that municipal treatment authorities and the U.S. EPA estimate the expenditures required to meet existing technology and water quality standards and to provide for replacement or expansion of facilities as necessary to serve the population projected to 2000. Thus, a "need" consists of the resources associated with the upgrading, replacement, expansion, or construction of treatment facilities which federal, state, and local governments consider to be necessary, based upon the federal standards, or more stringent state standards.

Details of the Needs Survey may be found in a separate report, "1982 Needs Survey--Cost Estimates for Construction of Publicly-Owned Wastewater Treatment Facilities," EPA-430-9-82-009, December 31, 1982.

Defining Cost. The estimate of municipal costs is based on an assessment of the expenditures that will be required to meet existing technology and water quality standards and to provide for replacement or expansion of wastewater treatment facilities. It is not an estimate of projected outlays by federal, state, and local governments to construct or operate these facilities. During the period 1971 through 1982, federal outlays or construction grants amounted to roughly $30 billion. Assuming a state cost share of 25 percent would bring total outlays to $40 billion.

Table W2.2. Total municipal expenditures for water pollution control 1/ (historical and projected costs in millions of 1981 dollars)

Year	Capital expenditures 2/	Operation and maintenance
1972	6,258	2,193
1973	6,774	2,459
1974	7,476	2,657
1975	7,709	2,719
1976	8,192	3,031
1977	7,828	3,384
1978	9,114	3,670
1979	9,084	3,875
1980	8,198	4,099
1981	6,539	4,492
1982	5,936	4,640
1983	5,936	4,891
1984	5,936	5,143
1985	5,936	5,394
1986	5,936	5,645
1987	5,936	5,897
1988	5,936	6,148
1989	5,936	6,399
1990	5,936	6,651
1991-2000	59,360	80,330
Total	189,962	163,717

1/ Expenditures apply to wastewater treatment facilities and sewer systems, but do not include costs incurred for stormwater control systems.

2/ Capital expenditures include funds from federal construction grants and matching funds from state and local governments.

Sources: 1972-1981: Rutledge, Gary L., "Pollution Abatement and Control Expenditures in Constant and Current Dollars," 1972-81, "Survey of Current Business," February 1983 (current dollars were converted to 1981 dollars for Table 2.2).

1982-2000: Capital expenditure projections are based on needs of $112.79 billion in 1981 dollars and an assumption of uniform annual expenditures. The needs are based on the estimate of $118.36 billion in 1982 dollars, as given in U.S. EPA, 1982 Needs Survey - Cost Estimates for Construction of Publicly-owned Wastewater Treatment Facilities, December 31, 1982, p. 6. Operation and Maintenance (O&M) cost projections are based on extrapolation of 1972-1981 data by least squares linear regression. Although some of the capital expenditures will be for new facilities to replace obsolete existing facilities and O&M costs would not be expected to increase for such new facilities, this condition has existed in the past. Therefore, annual increases in O&M costs according to historical trends are expected.

Not all costs reported herein are properly attributable to the standards created under the authority of P.L. 92-500. The costs attributable to those standards are incremental. Only those costs associated with upgrading from an existing level of treatment to a higher level of treatment necessary to meet technology and water quality objectives are properly attributable to the standards. Thus, costs for replacement of facilities built prior to 1972 which do not require a different level of treatment, the cost associated with the lower level of treatment than would otherwise have been achieved in facilities built after 1972, and the cost associated with a higher level of treatment than is necessary to meet the standards should be excluded from the costs attributed to meeting standards. However, since Section 516(b) directs assessment of the costs of "carrying out the provisions of the Act," and the construction grant program is an integral part of the Act, the entire range of costs attributed to that program are reported herein.

Actual capital expenditures and operation and maintenance costs, in 1981 dollars, are reported in Table W2.2 for 1972 through 1981. Projections are given for 1982 to 2000.

Categories of Need. The joint State/EPA estimates of the cost of constructing publicly owned treatment works needed to meet the 1983 goals of the Act are divided into six major categories which are outlined in the 1982 Needs Survey. All six categories are briefly described below.

Category I. Secondary Treatment. This category includes the costs which facilities incur to achieve secondary levels of treatment, regardless of the treatment levels required at the facility site. Outfall sewers are also included in this category. Incremental costs for treatment levels beyond secondary treatment were reported in Categories IIA and IIB.

Costs for systems designed to serve individual residences are reported in Category I. For purposes of the Survey, "best practicable wastewater treatment technology (BPWTT)" and secondary treatment were considered synonymous.

Category IIA. Advanced Secondary Treatment (AST). Incremental costs which are incurred to achieve advanced secondary levels of treatment are reported for those facilities that must achieve these levels. This requirement generally exists when water quality standards require removal of standard pollutants at levels higher than 85 percent or 30/30, but less than 95 percent removal, or 10/10.

Category IIB. Advanced Treatment (AT). Incremental costs above those incurred in Category IIA are reported for facilities which require advanced levels of treatment. This requirement generally exists where water quality standards require removal of such pollutants as phosphorus, ammonia, nitrates, or organic and other substances. In addition, this requirement exists where removal requirements for conventional pollutants exceed 95 percent.

Category IIIA. Correction of Infiltration/Flow. These costs are for correction of sewer system infiltration/inflow problems. Costs are also reported for preliminary sewer analysis and a detailed sewer system evaluation survey.

Category IIIB. Major Rehabilitation of Sewers. Requirements for replacement and/or major rehabilitation of existing sewage collection systems are reported in this category. Costs are to be reported if corrective actions are necessary to maintain the total integrity of the system. Major rehabilitation is considered extensive repair of existing sewers beyond the scope of normal maintenance programs, e.g. where sewers are collapsing or are structurally unsound.

Category IVA. New Collector Sewers. This category consists of the costs of constructing new collection systems in existing communities, and appurtenances designed to correct violations caused by raw discharges. The cost of protecting public health from such things as malfunctioning septic tanks is also included.

Category IVB. New Interceptor Sewers. Included in this category are costs for new interceptor sewers and transmission pumping costs necessary for bulk transport of wastewaters from collector sewer systems to treatment facilities.

Category V. Control of Combined Sewer Overflow (CSO). Costs reported for this category are to prevent periodic bypassing of untreated wastes from combined sewers to an extent violating water quality standard or effluent limitations. This category does not include treatment and/or control of stormwaters in separate storm and drainage systems, nor costs for flood control or drainage improvement.

Category VI. Control of Stormwater Runoff. Costs in this category are for abating pollution in urbanized areas from stormwater runoff channeled through sewers and other conveyances used only for such runoff. The costs of abating pollution from stormwaters channeled throug combined sewers that also carry sewage are included in Category V. Category VI was added so the survey would provide an estimate of all eligible facility costs, as explicitly required by P.L. 93-243.

The estimates were reported in January 1982 dollars, and the present population was defined as the U.S. population as estimated by the 1980 Census. The future population was projected for the year 2000 by th Bureau of Economic Analysis.

Results of the Survey. The results of the 1982 Needs Survey ar presented in Table WQ.3 in aggregate national totals, by category. Variou subtotals are presented to give an indication of needs versus priorities. State-by-state data for the same categories may be found in the aforementioned separate report.

Assessment of Backlog. An addition to the Needs Survey in 1976 was the assessment of need for present populations (the backlog of need).

Table W2.3. Summary table of national estimates for construction of publicly-owned wastewater treatment facilities (billions of 1981 dollars)

Needs category	2000 EPA assessment	Backlog estimate
I (Secondary Treatment)	29.67	19.18
IIA Advanced Secondary Levels	4.64	3.10
IIB Advanced Treatment Levels	.83	.50
IIIA (Infiltration/Inflow)	2.44	2.44
IIIB (Replacement/Rehabilitation)	4.47	4.47
IVA (New Collector Sewers)	19.69	15.98
IVB (New Interceptor Sewers)	16.99	8.51
V (Combined Sewer Overflows)	34.06	34.06
Total Treatment (I, II)	35.14	22.79
Total I, II, IIIA and IVB	54.57	33.74
Total I-V	112.79	88.25

Source: U.S. EPA 1982 Needs Survey - Cost Estimates for Construction of Publicly-Owned Wastewater Treament Facilities, December 31, 1982, p. 6.

This assessment was retained in 1982, and the needs for the present population, Categories I-V, are estimated to be $92.60 billion. Note that because combined sewer systems are no longer built, Category V needs are exclusively backlog needs.

The costs reported for the backlog are sufficient only for the facilities necessary to serve the 1980 population. They do not include any costs for the reserve capacity which would be required by the Act to be included in these facilities for population growth beyond 1980. They also exclude estimates for treatment and sewers that were not necessary in 1980, but are projected to be necessary for populations in the year 2000.

Aggregate Costs

The aggregate costs reported in Table W2.4 include the following components:

- Federal and state program expenditures as listed in Table W2.1, which are taken as operating costs
- Municipal expenditures as listed in Table W2.2, divided between Capital Investment (including construction grants) and O&M costs as shown in that table.

Table W2.4. Government expenditures

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (BIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	6539.00	53350.98	23820.99	41628.98	59962.96
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10146.12	26559.37	27641.13	62762.07	127638.27
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	5373.00	26313.00	15321.90	32638.98	64109.96
ANNUAL CAPITAL + O&M	15519.12	52872.37	42963.12	95401.05	191748.23
ALL ANNUAL COSTS	15519.12	52872.37	42963.12	95401.05	191748.23

Chapter W3. Energy Industries

For the purpose of this report, the broad category "Energy Industries" was defined to include those industries that gather, transfer, process, and deliver energy to the ultimate user. These include:

- Coal Mining
- Oil and Gas Extraction
- Petroleum Refining
- Steam-Electric Power Generation

Costs for the reduction of water pollution for these industries are summarized in Table W3. These costs and other data are repeated below in the appropriate sections together with the assumptions specific to the industry and other details.

TABLE W 3. ENERGY INDUSTRIES WATER POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
				INVESTMENT		
W 3. 1	COAL MINING	5.77	74.88	17.44	28.76	77.05
W 3. 2	OIL & GAS EXTRACTION	0.0	1290.90	0.0	0.0	71.56
W 3. 3	PETROLEUM REFINING	106.66	3150.38	264.00	535.03	377.69
W 3. 4	POWER PLANTS	17.08	599.26	28.47	113.90	166.98
	TOTAL INVESTMENT	129.52	5115.42	309.91	677.68	693.27

CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
				ANNUAL COSTS		
W 3. 1	COAL MINING	85.92	224.72	238.21	523.31	1010.89
W 3. 2	OIL & GAS EXTRACTION	570.97	1310.68	1683.23	3462.36	6185.62
W 3. 3	PETROLEUM REFINING	983.83	3088.64	2659.16	5850.52	10304.06
W 3. 4	POWER PLANTS	307.58	1331.42	901.95	1899.18	3452.85
	TOTAL ANNUAL COSTS	1948.30	5955.45	5482.53	11735.38	20953.41

Chapter W3.1 Coal Mining

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. EPA promulgated BPT, BAT, and NSPS in November 1982 for the coal mining industry. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the coal mining industry is not reflected in the text of the chapter or the cost estimates included in Table W3.1.1. The cost estimates represent the impact of BPT regulations promulgated and BAT and NSPS regulations proposed in 1975.

Industry Characteristics

Control costs are based on the assumption that industry capacity will grow from its 1976 level of 735 million metric tons (820 million short tons) to 920 million metric tons (1.03 billion short tons).

Pollutants and Sources

The disruption of the earth's surface by mining operations causes chemical and physical modifications that often adversely affect both surface- and ground-water resources. The major causes of concern are sedimentation from disturbed areas and acid mine drainage discharges.

Although coal mining activities exist in numerous states, acid mine drainage is a more critical problem in the eastern coal fields. Because of limited coal production, variations in mining practices, lack of precipitation, abundance of limestone, high natural alkalinity of surface water, and scarcity of acid-forming materials in some coal producing areas, the distribution of acid mine drainage varies markedly from state to state and within the states. While significant areas of disturbed land may be identified in most states, the estimated costs of abating acid mine water pollution developed for this report are based on the treatment of water from active operations, assuming compliance with all promulgated (BPT) and proposed (BAT, NSPS) regulation.

Costing Methodology

Bituminous and Lignite Coal Control Costs. Mine water must be pumped out to allow mining to continue. This technique is also used to prevent aquifers from being polluted by metals in solution, COD, and acid formation (although flooding the mine may also prevent acid formation). To develop costs for BPT, BAT, and NSPS compliance, "Economic Document" model plants and costs were used for BPT and NSPS compliance levels. For BAT compliance costs, neutralization equipment, chemicals, and distribution piping and pumps remained the same but the settling pond was doubled in size and cost, and limited amounts of flocculation agents were added. To determine costs for BPT and BAT level compliance, production for 1976, 1982, and 1986 was split into large, medium, and small model mines. It was assumed that all mines will require treatment at least for suspended solids and pH.

Anthracite Coal Control Costs. Anthracite coal is showing a long term decreasing production trend. Control costs were estimated using model facility costs as in the previous section. In estimating mine pumpout treatment costs it was assumed that 42 percent of yearly production is surface mined and 10 percent is deep mined (the remainder is assumed to be comb, bank, and auger mined). Because the production rate of anthracite is decreasing, it was assumed that treatment facilities equivalent to 6.4 million metric tons (7 million short tons) per year capacity would be required to install water treatment facilities.

This methodology has overstated costs in that many cleaning plants are at the "mine mouth", and mine pumpout is often used as process water in the cleaning plant (the effluent then needs treatment only once).

The resulting estimated costs of compliance are listed in Table W3.1.1.

Table W3.1. Coal mining

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	65.37	0.67	0.67	40.34
BAT	1.78	0.0	5.33	7.11	3.56
NEW PLANTS (NSPS)	4.01	9.60	11.48	21.03	32.94
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	5.78	74.97	17.49	28.82	76.83
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	8.68	30.61	26.05	52.10	86.72
BAT	0.70	0.0	1.40	4.21	9.11
NEW PLANTS (NSPS)	2.77	2.74	6.76	17.78	46.01
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	12.16	33.35	34.21	74.08	141.85
O + M					
EXISTING PLANTS					
BPT	48.75	171.76	146.25	292.51	487.51
BAT	8.73	0.0	17.46	52.39	113.50
NEW PLANTS (NSPS)	16.42	18.94	40.58	105.20	269.84
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	73.91	190.69	204.30	450.10	870.86
ANNUAL CAPITAL + O+M	86.06	224.05	238.51	524.18	1012.71
ALL ANNUAL COSTS	86.06	224.05	238.51	524.18	1012.71

Chapter W3.2 Oil and Gas Extraction

Regulations

Proposed regulations for NSPS, BAT, and pretreatment for the industry covered in this chapter were revoked. In addition, existing BPT standards have been revoked for some subcategories. The Agency is developing guidelines for NSPS and investigating the need for BAT requirements. Because of the uncertainty regarding future pollution abatement requirements this chapter has not been updated. The costs shown are for the BPT requirements.

Industry Characteristics

The extraction of gas and oil through the use of conventional wells, the subject of this chapter, constitutes all of the commercial activity in SIC category 1311 since the other activities (producing oil from oil sands and oil shale) are at the present time only in the research and development stage in the United States. The extraction of oil and gas consists of the production from wells onshore and offshore. The largest number of wells are onshore or in coastal waters. Most of the far-and near-offshore platforms are located in the Gulf of Mexico off the coast of Louisiana. The offshore wells beyond the historic state limit, in what is known as the Outer Continental Shelf (or Far Offshore) Waters are under Federal jurisdiction. Wells in Offshore waters inside the State limit are classified as being in Near Offshore Waters. The bayous and estuaries of Louisiana and Texas are known as Coastal Waters. In the Coastal Waters, things are complicated because water from a well onshore may discharge its formation water to a nearby bayou or a platform built out in the water may pipe its formation water onshore for treatment followed by dumping or injection. The onshore wells can be subdivided into stripper wells, wells with beneficial use of formation water, and other nonstripper wells. Stripper wells are those that produce 10 barrels of oil per day or less. Wells that produce water that is sufficiently low in salinity that it can be used for agricultural or livestock watering purposes constitute the beneficial use category. The balance of the onshore wells in the United States can be categorized as other nonstripper onshore wells. The pollution regulations discussed below are grouped by these categories.

The interrelation of gas and oil production is complex. When oil and gas are found together, the usual case, the gas is spoken of as being associated gas. Gas from wells having no oil production is called nonassociated gas. However, the nonassociated gas has a high content of vapors of petroleum liquids; before the natural gas is put into the pipeline, these vapors are condensed and sold as natural gas liquids. (This activity is discussed in the section of the Clean Air Report on

Natural Gas Processing). Some oil wells have so little associated gas that it is not economical to bring this gas to a pipeline.

Gas wells have been included for the offshore region since these data were readily available and the costs of the proposed regulations are high. Nonassociated gas wells onshore have been ignored in this study as well as in the EPA studies done previously since the pollution problems involved are minor.

Pollutants and Control Technology

The chief pollutant from the operation of oil and gas wells onshore is the brine that is produced with the oil and gas. (In certain areas of the West, the water is low in salts and is acceptable for watering stock.) There are a number of ways to handle brine produced onshore. It can be stored in a pit and allowed to evaporate, or it can be reinjected beneath the surface. The last is by far the most common disposal technique.

Although the salts in the brine are nonpolluting when added to ocean water, the oil dispensed in the brine is a potential pollutant. The oil-laden water can be treated with coalescents and dissolved air flotation equipment to lower the oil content to an acceptable level before discharge to the ocean. If complete elimination of oil discharge is desired, injections into underground strata can be used, although this is expensive, especially if the well is in deep water. In the regions close to shore, it is also possible to send the water ashore by pipeline for treatment followed by dumping, reinjection, or by evaporation from a pit area.

One way to increase the total amount of oil that is recovered is to inject water into the formation, a process known as water flooding. Very frequently, the production water is reinjected. Since this is an economic use of the water and is not related to the pollution abatement that is obtained as an incidental by-product, the cost of reinjection for purposes of secondary recovery is not included in this report.

Another source of pollution is oil from drill cuttings and from spent muds that are discharged. Water-based muds and drill cuttings can be washed before dumping offshore. Onshore, they can be landfilled. Oil-based muds used offshore can be collected and hauled ashore and then disposed of in a landfill. Hauling to shore is also used to dispose of refuse and toxic chemicals from platforms. Water running off the deck of a platform is another possible source of pollution since the deck is frequently spotted with oil. Deck washings and rainwater can be collected and treated in the same manner as the produced water. Another potential source of water pollution is the sanitary sewage water. This can be treated, chlorinated and discharged. All of the above potential sources of pollution are from activities that are more or less expected in everyday operations. The prevention of blowouts and catastrophic spills is not treated here.

Costing Methodology

Each of the states where oil and gas is produced has its own set of regulations governing the discharge of water, casing depth, and reinjection of water, as well as the disposal of solid waste from drilling and operation of the well. Since the coastal states have jurisdiction out to their historic boundary (usually 3 miles, but in the case of Texas, 9 miles offshore), they also promulgate regulations concerning possible pollutants from offshore oil and gas rigs and platforms in the coastal and near offshore waters. The State of California has a limit of 20 parts per million for the long-term average of oil and grease. Louisiana's limit is 30 ppm. In Texas, a permit is issued for each platform based on the potential impact on the local water quality. Some of the permits in sensitive areas have a limit of oil and grease as low as 25 ppm. In the area of Federal control, the outer continental shelf, the U.S. Geological Survey (USGS) has the authority to issue regulations designed to protect the environment and to make navigation safe. For example, the USGS's regulations limit the average oil and grease discharge to no more than 50 ppm.

The costs given in the Development Document were used for the contiguous 48 states. The Alaskan offshore platforms pipe their produced formation water to shore where it is treated and dumped. The costs for Alaska are assumed to be about three times as high as they would be for the contiguous 48 states. (The water is treated and dumped even though the fields use water for secondary recovery. This is because the produced formation water is incompatible with the seawater that is used for the repressurization of the reservoir.) No costs for disposal of oil from onshore wells in Alaska were included because of a lack of data.

EPA requirements concerning the disposal of trash, drill cuttings, spent mud, and sanitary wastes from offshore platforms duplicate requirements that were in the various state or U.S. Geological Survey Regulations. Hence, no incremental costs are occasioned by the Clean Water Act. The cost of extra casing to meet the Clean Drinking Water Act's provisions have not been included in this analysis.

Growth of Unit Numbers. The growth of the number of discharge points in the offshore region was estimated as follows. For the coastal and near offshore regions, it was assumed that the number of abandonments would equal the number of new wells so that there would be no net growth. For the far offshore, the historic rate of growth of platforms was used as an approximation of the growth with the number of discharge points, using data from Offshore (June 20, 1977). For 1977-1978, a 10 percent increase was assumed; for 1979-1985, 15 percent per year. These percentages include expected growth in the Gulf of Alaska and offshore Atlantic. The growth rate for onshore well numbers is based on the Project Independence Report using the "Business-as-usual" scenario.

The cost of abatement of pollution problems in oil and gas extraction has been calculated to be as shown in Table W3.2.1.

Table W3.2.1. Oil and gas extraction

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .229E+08

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	1290.91	0.0	0.0	71.56
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	1290.91	0.0	0.0	71.56
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	169.72	403.59	509.16	1018.32	1700.33
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	169.72	403.59	509.16	1018.32	1700.33
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	401.25	907.10	1174.07	2444.05	4485.31
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	401.25	907.10	1174.07	2444.05	4485.31
ANNUAL CAPITAL + O+M	570.97	1310.68	1683.23	3462.37	6185.65
ALL ANNUAL COSTS	570.97	1310.68	1683.23	3462.37	6185.65

Chapter W3.3 Petroleum Refining Industry

Regulations

The costs of the petroleum refining industry for water pollution control were based on regulations promulgated by EPA on October 18, 1982. These regulations provide effluent limitations guidelines for BAT, new source performance standards (NSPS), pretreatment standards for existing sources (PSES) and for new sources (PSNS) (47FR46434). BAT was promulgated at the same level as BPT (40FR419). NSPS, PSES and PSNS regulations were left at existing cost levels (42FR15684). BPT regulations are detailed in the Code of Federal Regulations (40CFR419).

Industry Characteristics

As of January 1, 1979, the petroleum refining industry comprised 174 firms operating 308 refineries in 42 states and Puerto Rico, the Virgin Islands and Guam. (In addition there are some small asphalt plants that are shut down in the winter.) All refineries are necessarily multiproduct but range from simple to complex. The size distribution of these refineries is shown in Table W3.3-1. As of January 2, 1979 the 16 largest firms accounted for 74 percent of the industry's operating capacity. The number of refineries and capacity for refineries operated by the large firms are shown in Table W3.3-2.

The petroleum industry produces hundreds of different products in refineries, which can be grouped in six major categories: gasoline (44%), jet fuel (6.5%), middle distillates (21%), residual fuel oil (11%), liquefied refinery gases (2.5%) and others, such as lubricants, waxes, asphalt and petrochemical feedstocks (15 percent). (Percentages are by volume for 1979.) Although crude oil is the most important refinery feedstock, natural gasoline and other natural gas liquids provide about 7 percent of hydrocarbon refinery inputs.

Although a typical oil refinery is technically complex, the process is conceptually simple. Crude oils, which are liquid mixtures of many carbon-containing compounds, are first separated into several fractions of varying molecular size The chemical composition of some of these fractions is then altered by changing the average molecular size and/or the structure of the molecules. Many of the intermediate fractions are "treated" to make the impurities innocuous or to remove them completely. These are then blended to produce finished products, to which various substances, known as additives, may be added to impart certain desirable properties.

In general, the number and complexity of refining operations increases with increasing refinery size. Most of the simple topping refineries are small while the petrochemical and integrated refineries are generally large. There are some fairly small lube oil refineries.

Table W3.3-1. Refinery distribution by size, operating as of Jan. 1, 1979, US and territories (in thousands of cubic meters per calendar day with thousands of barrels per calendar day in parentheses)

Capacity Range	Number of Refineries	Total Capacity	Total Industry Capacity (%)	Average Capacity
(Up to 4.9) Up to 0.078	44	(111) 17.6	0.6	(2.5) 0.4
(5 to 24.9) 0.079 to 3.96	113	(1,378) 219	7.5	(12.2) 1.9
(25 to 74.9) 3.97 to 11.8	80	(3,577) 569	19.7	(44.7) 7.1
(75 to 149.9) 11.9 to 23.7	40	(4,173) 663	22.9	(104.3) 16.6
(150 to 449.9) 23.8 to 71.4	28	(7,121) 1,132	39.2	(254.3) 40.4
(450 and over) 71.5 and over	3	(1,840) 293	10.1	(613.3) 97.5
Totals	308	(18,200) 2,894	100.00	(59.1) 9.4

Table W3.3-2. The refinery inventory--operating capacity, Jan. 1, 1979 by operator (capacity in thousands of cubic meters per calendar day with thousands of barrels per calendar day in parentheses)

	Number of refineries	Crude capacity		Crude capacity (%)
Exxon	5	250	(1,574)	8.6
Chevron	11	230	(1,450)	7.9
Amoco	10	197	(1,238)	6.8
Shell	8	179	(1,123)	6.2
Texaco	12	168	(1,059)	5.8
Gulf	8	218	(1,371)	7.5
Mobil	7	143	(901)	4.9
Atlantic Richfield	5	135	(847)	4.6
Amerada Hess	2	116	(730)	4.0
Sun Oil	5	90	(569)	3.1
Marathon	4	85	(533)	2.9
Union Oil	5	78	(490)	2.7
Sohio/BP	3	72	(452)	2.5
Ashland	6	58	(365)	2.0
Conoco	8	58	(363)	2.0
Phillips	5	48	(302)	1.7
Subtotal	104	2125	(13,367)	73.2
Remaining Firms	204	777	(4,884)	26.8
Total	308	2,902	(18,251)	100

Pollutants and Sources

Wastewater pollutants generated in the various refining processes, such as BOD, COD, total organic carbon, total suspended solids, oil and grease, phenols, ammonia, sulfides, chromium, and acids or bases, are present in untreated refinery effluent. Some pollutants enter the wastewater directly from processing, while others enter the waste stream from washing tanks, equipment catalysts, etc., from cooling water blowdown, and from leaks and spillage. Additional flows and waste loads are created by storm water runoff from the refinery grounds and from the disposal of tanker ballast water.

The following parameters are covered under the effluent limitations guidelines: BOD_5, total suspended solids, COD, oil and grease, phenolic compounds, ammonia (as N), sulfide, total chromium, hexavalent chromium, and pH. The effluent limitations for each pollutant vary with the type, size and complexity of the refinery.

Control Technology

Wastewater treatment processes currently used in the petroleum refining industry include equalization and storm water diversion; initial oil and solids removal (API separators or baffle plate separators); further oil and solids removal (clarifiers, dissolved air flotations, or filters); carbonaceous waste removal (activated sludge, aerated lagoons, oxidation ponds, trickling filter, activated carbon, or combinations of these); and filters (sand or multi-media) following biological treatment methods.

BPT guidelines are based upon both in-plant and end-of-pipe control practices widely used within the industry. These include the above listed end-of-pipe technologies plus:

- Installation of sour water strippers to reduce the sulfide and ammonia concentrations entering the treatment plant.
- Elimination of once-through barometric condenser water by using surface condensers or recycle systems with oily water cooling towers.
- Segregation of sewers, so that unpolluted storm runoff and once-through cooling waters are not treated, along with the process and other polluted waters.
- Elimination of polluted once-through cooling water by monitoring and repair of surface condensers or by use of wet and dry recycle systems.

NSPS includes discharge flow reduction of from 25 to 50 percent of average BPT flow, depending on subcategory, achieved through greater reuse and recycle of wastewaters in addition to BPT treatment.

The reduction of oil and grease and ammonia based on oil/water separation and steam stripping technologies is the basis for both PSES and

PSNS. Also a mass limitation for ammonia is included for both for indirect dischargers consists solely of "sour" waters.

Costing Methodology

All costs were estimated exogeneously using published EPA cost estimates (EPA 440/1-79/0246, Dec., 1979) and the October 18, 1982 Federal Register. Due to reductions in world petroleum markets no additional new grass roots refineries will be built after 1982.

The aggregate costs developed on this basis are given in Table W3.3.3.

Table W3.3.3. Petroleum refining industry

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.0 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	106.66	3150.38	264.00	535.03	377.69
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	448.90	1464.92	1307.16	2744.35	4456.65
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	534.93	1623.72	1351.99	3106.19	5847.43
ANNUAL CAPITAL + O+M	983.84	3088.64	2659.16	5850.53	10304.08
ALL ANNUAL COSTS	983.84	3088.64	2659.16	5850.53	10304.08

Chapter W3.4. Steam Electric Power Generating Industry

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. EPA promulgated BAT, NSPS, PSES, and PSNS in November 1982 for the steam electric power generating industry. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the steam electric power generating industry is not reflected in the text of the chapter or the cost estimates included in Table W3.4.2. The cost estimates represent the impact of regulations as proposed in 1980.

Industry Characteristics

The steam electric power industry can be subdivided according to the type of fuel consumed in the production of electricity, i.e., fossil fuels (coal, gas, and oil) and nuclear fuels. Table W3.4.1 illustrates the recent and projected distribution of steam plants and capacity among the major fuel types.

Table W3.4-1. Capacity categorization by fuel type
(Capacity in gigawatts)

	1978	1985	1990	1995
Coal Capacity	227.4	301.8	365.1	473.9
Number of Plants	352	467	565	734
Oil/Gas Capacity	170.1	173.5	157.4	100.4
Number of Plants	429	438	397	253
Nuclear Capacity	53.8	139.0	173.1	281.0
Number of Plants	38	98	122	198

Pollutants and Sources

Effluent guidelines promulgated October 8, 1974 (39 FR 36186-36207) control the following pollutants:

- pH
- PCB
- TSS
- Oil and grease
- Total copper
- Total iron
- Free available chlorine
- Total residual chlorine
- Corrosion inhibitors
- Zinc
- Chromium
- Phosphate

Main sources contributing to the total waste load are:

- Low volume wastes which include scrubber waters, discharge from ion exchange treatment systems, water treatment, evaporator blowdown, laboratory and sampling streams, floor drainage, cooling tower basin cleaning wastes, and blowdown from recirculating house service water systems

- Metal cleaning wastes
  - Ash transport water
  - Boiler and cooling tower blowdown
  - Area runoff from material storage and construction areas.

Control Technology

A variety of control and treatment technologies are in use by or available to the steam electric power generating industry. Thus water management programs vary among plants.

The amount of heat rejected to available waters is reduced by in-process means, use of cooling towers, and by dissipating the heat in on-property cooling ponds or lakes.

Clarification, flotation, and filtration are common methods of removing suspended solids. Chemical reduction, ion exchange, and chemically induced precipitation are among the methods used to control metals in wastewater. Oil and grease are removed by skimming, flotation, demulsification, and coagulation.

Approaches to controlling chlorine in effluents involve reducing dosage frequency, amount, and/or duration, splitting the effluent into two streams and chlorinating one stream at a time, use of feedback control systems, dissipation, and aeration.

The following technologies were considered in the economic analysis made recently of the revised effluent guidelines of BAT, NSPS, PSES and PSNS.

- Dry fly ash handling
- Chemical precipitation (fly ash transport water)
- Dechlorination (cooling water)
- Chlorine minimization (cooling water)
- Dechlorination and chlorine minimization (cooling water).

Costing Methodology

Compliance costs were adapted on an empirical basis from economic analyses performed for EPA by Temple, Barker, and Sloane, Inc. Costs associated with recent revisions of regulations were taken from the report dated August, 1980. Costs for compliance with regulations not covered by the August, 1980 report were based on the prior similar study of May 1976.

The aggregated costs, as developed from those documents and updated to 1981 dollars, are given in Table W3.4.2.

Table W3.4.2. Steam electric power generating industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	17.08	599.26	28.47	113.90	166.98
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	82.53	353.57	241.60	510.16	833.76
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	225.05	977.85	660.35	1389.03	2619.09
ANNUAL CAPITAL + O+M	307.58	1331.42	901.95	1899.19	3452.85
ALL ANNUAL COSTS	307.58	1331.42	901.95	1899.19	3452.85

Chapter W4. Chemicals Industries

For the purpose of this report, the Chemicals Industries are defined as those establishments which manufacture products primarily by chemical modification of raw materials and for which the final product is a chemical. These include:

- Organic Chemicals Industry
- Inorganic Chemicals
- Plastics & Synthetics
- Rubber Manufacturing
- Soaps and Detergent Industry
- Carbon Black Industry
- Explosives Industry
- Pesticides and Agricultural Chemicals
- Fertilizer Manufacturing Industry
- Phosphorus Chemicals Industry
- Paint Formulating
- Printing Ink Formulating
- Photographic Processing
- Textiles Industry

The textiles industry has been included in this grouping primarily because it is largely the chemical operations within that industry which are responsible for water pollution. Costs associated with the implementation of the FWPCA for the Chemicals Industries are summarized in Table W4.

TABLE W 4. CHEMICAL
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 4. 1	ORGANIC CHEM.	254.23	3049.80	800.85	1801.18	5021.27
W 4. 2	INORGANIC CHEMICALS	8.76	224.44	13.30	34.41	137.18
W 4. 3	PLASTICS & SYNTHETICS	105.97	531.92	282.69	722.62	2914.31
W 4. 4	RUBBER MFG.	7.96	214.72	13.14	38.03	160.80
W 4. 5	SOAPS & DETERGENTS	0.34	5.38	0.97	2.59	5.20
W 4. 6	CARBON BLACK	0.50	0.93	1.50	3.85	3.32
W 4. 7	EXPLOSIVES	0.0	1201.81	0.0	0.0	0.0
W 4. 8	PESTICIDES	0.0	37.63	0.0	0.0	0.0
W 4. 9	FERTILIZER MFG.	46.68	208.50	135.72	239.59	403.58
W 4.10	PHOSPHATE MFG.	10.43	71.94	22.76	42.37	54.57
W 4.11	PAINT FORMULATING	1.36	13.21	3.80	8.58	24.49
W 4.12	PRINTING INK FORMULATING	0.0	2.88	0.0	0.0	0.0
W 4.13	PHOTOGRAPHIC PROCESSING	0.0	3.72	0.0	0.27	4.95
W 4.14	TEXTILES	5.11	59.85	19.55	45.97	122.12
	TOTAL INVESTMENT	441.33	5626.73	1294.28	2939.46	8851.77

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 4. 1	ORGANIC CHEM.	759.96	1416.26	2128.12	4779.76	11133.57
W 4. 2	INORGANIC CHEMICALS	91.43	273.25	262.67	558.85	1033.25
W 4. 3	PLASTICS & SYNTHETICS	150.40	277.47	393.02	1001.44	3318.03
W 4. 4	RUBBER MFG.	54.27	163.99	156.79	335.24	671.37
W 4. 5	SOAPS & DETERGENTS	1.23	2.33	3.51	7.82	16.76
W 4. 6	CARBON BLACK	0.40	0.23	0.96	3.13	7.62
W 4. 7	EXPLOSIVES	236.05	711.88	708.14	1416.29	2298.92
W 4. 8	PESTICIDES	9.52	28.76	28.57	57.14	93.31
W 4. 9	FERTILIZER MFG.	153.44	252.59	403.28	961.02	2251.55
W 4.10	PHOSPHATE MFG.	27.02	44.50	70.98	171.29	383.62
W 4.11	PAINT FORMULATING	4.13	10.48	11.42	26.06	61.05
W 4.12	PRINTING INK FORMULATING	0.51	2.22	1.52	3.04	4.39
W 4.13	PHOTOGRAPHIC PROCESSING	1.82	4.90	5.31	11.08	21.22
W 4.14	TEXTILES	26.72	60.17	74.49	167.36	355.10
	TOTAL ANNUAL COSTS	1516.89	3249.00	4248.78	9499.52	21649.75

Chapter W4.1 Organic Chemicals Industry

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. In 1983 EPA proposed new regulations for BPT, BAT, NSPS, PSES, and PSNS. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the organic chemicals industry is not reflected in the text of the chapter or the cost estimates included in Table W4.1.2. The cost estimates represent the impact of the regulations as originally promulgated.

Industry Characteristics

The organic chemicals industry includes a vast number of products and processes. The Phase I effluent limitations guidelines cover only part of the organic chemicals industry. At the time of this report, no Phase II regulations had been proposed for other parts of the organic chemicals industry. Primary petrochemical processing (i.e., chemicals produced at petroleum refineries), plastics, fibers, agricultural chemicals, pesticides, detergents, paints, and pharmaceuticals are not included. These are discussed elsewhere in this report.

Synthetic organic chemicals are derivative products of naturally occurring raw materials (petroleum, natural gas, and coal) which have undergone at least one chemical conversion. The organic chemicals industry was initially dependent upon coal as its sole source of raw materials. However, during the last three decades it has moved so rapidly from coal to petroleum-based feedstocks that the term "petrochemicals" has come into common use.

The basic raw materials are usually obtained by physical separation processes in petroleum refineries. The raw materials are then chemically converted to a primary group of reactive precursors; these precursors are then used in a multitude of specific chemical conversions to produce both intermediate and final products.

Processing of organic chemicals usually involves four stages:

- Feed preparation -- vaporization, heating, compressing, and chemical or physical purification of raw materials
- Reaction -- the reaction of the raw materials, frequently in the presence of a catalyst
- Product separation -- condensation, distillation, absorption, etc., to obtain the desired product

- Product purification -- distillation, extraction, crystallization, etc., to remove impurities.

Processing methods may be carried out either in continuous operations or in individual batches. Facilities using the continuous processing method manufacture products at much greater volumes and at lower unit costs than those using batch methods.

The effluent limitations guidelines promulgated to date by EPA (for Phase I) apply only to those products of the organics chemicals industry produced in continuous processing operations. These operations have been divided into seven subcategories, based first upon the degree of process water used, and second upon the raw waste loads generated; Table W4.1.1 lists the seven subcategories and the products and processes included.

Pollutants and Sources

Water is used in many production processes as a reaction vehicle, and also as a vehicle to separate or to purify the final products by scrubbing, steam stripping, or absorption. In addition, a considerable amount of water is used for heating (steam) and cooling, and for washing reaction and storage vessels, etc.

The effluent limitations guidelines for the organic chemicals industry cover the following pollutants: BOD, COD, total suspended solids, phenols, and pH. The limitation placed upon pH in all cases is between 6.0 and 9.0. It should be noted that process wastewaters subject to limitations include all process waters exclusive of auxiliary sources, such as boiler and cooling water blowdown, water treatment backwash, laboratories, and other similar sources.

Control Technology

Technologies employed in the organic chemicals industry for the control of wastewater pollutants include in-process modifications, pollution control equipment, and end-of-pipe wastewater treatment. From a pollution-control standpoint, the most significant change that can be made in process chemistry is from a "wet" process to a "dry" process; that is, the substitution of some other solvent for water in which to carry out the reaction or to purify the product. Other in-process technologies observed or recommended for the organic chemicals industry include the substitution of surface heat exchangers for contact cooling water, the substitution of mechanical pumps for vacuum pump steam jet ejectors, the recycle of scrubber water, and the regeneration of contact process steam from contaminated condensate.

Biological treatment systems are the most common end-of-pipe technologies used in the organic chemicals industry today. These systems include activated sludge, trickling filters, aerated lagoons, and anaerobic lagoons. Other systems used include stripping towers, deep-well disposal, physical treatment, activated carbon, and incineration. Where phenols are

Table W4.1.1. Organic chemicals manufacturing industry products and related processes

Subcategory A	Nonaqueous Processes
Products	Process Descriptions
BTX Aromatics	Hydrotreatment of pyrolysis gasoline
BTX Aromatics	Solvent extraction from reformate
Cyclohexane	Hydrogenation of benzene
Vinyl Chloride	Addition of hydrochloric acid to acetylene
Subcategory B	Process with Process Water Contact as Steam Diluent or Absorbent
B1 Products	B1 Process Descriptions
Acetone	Dehydrogenation of isopropanol
Butadiene	Co-product of ethylene
Ethyl benzene	Alkylation of benzene with ethylene
Ethylene and propylene	Pyrolysis of naphtha or liquid petroleum gas
Ethylene dichloride	Direct chlorination of ethylene
Ethylene oxide	Catalytic oxidation of ethylene
Formaldehyde	Oxidation of methanol
Methanol	Steam reforming of natural gas
Methyl amines	Addition of ammonia to methane
Vinyl acetate	Synthesis of ethylene and acetic acid
Vinyl chloride	Cracking of ethylene dichloride
B2 Products	B2 Process Descriptions
Acetaldehyde	Dehydrogenation of ethanol
Acetylene	Partial oxidation of methane
Butadiene	Dehydrogenation of n-butane
Butadiene	Oxidative-dehydrogenation of n-butane
Styrene	Dehydrogenation of ethylbenzene
Subcategory C	Aqueous Liquid Phase Reaction Systems
C1 Products	C1 Process Descriptions
Acetic acid	Oxidation of acetaldehyde
Acrylic acid	Synthesis with carbon monoxide and acetylene
Coal tar	Distillation of coal tar
Ethylene glycol	Hydrogenation of ethylene oxide
Terephthalic acid	Catalytic oxidation of p-xylene
Terephthalic acid	Purification of crude terephthalic acid

Continued...

Table W4.1.1 (Continued)

C2 Products	C2 Process Descriptions
Acetaldehyde	Oxidation of ethylene with oxygen
Caprolactam	Oxidation of cyclohexane
Coal tar	Pitch forming
Oxo chemicals	Carbonylation and condensation
Phenol and Acetone	Cumene oxidation and cleavage
C3 Products	**C3 Process Descriptions**
Acetaldehyde	Oxidation of ethylene with air
Aniline	Nitration and hydrogenation of benzene
Bisphenol A	Condensation of phenol and acetone
Dimethyl terephthalate	Esterification of terephthalic acid
C4 Products	**C4 Process Descriptions**
Acrylates	Esterification of acrylic acid
p-cresol	Sulfonation of toluene
Methyl methacrylate	Acetone cyanohydrin process
Terephthalic acid	Nitric acid process
Tetraethyl lead	Addition of ethyl chloride to lead amalgam

Source: EPA Development Document, April 1973, pp. 28-29 present in wastewaters, they may be removed by solvent extraction, carbon absorption, caustic precipitation, or steam stripping. Cyanide may be removed by oxidation.

In-process controls commensurate with BPT include segregation of waste streams, the substitution of nonaqueous media in which to carry out the reactions or to purify the products, recycling or reuse of process water, and the recovery of products and byproducts from the wastewaters by solvent extraction, absorption, or distillation. End-of-pipe treatment commensurate with BPT is based on the use of biological systems as mentioned above. These systems include additional treatment operations such as equalization, neutralization, primary clarification with oil removal, nutrient addition, and effluent polishing steps, such as coagulation, sedimentation, and filtration. Phenol removal is also required in some cases.

Technology commensurate with BAT includes the additional of activated carbon to the BPT biological systems to achieve substantial reductions of dissolved organic compounds. In-process controls applicable to BAT include:

- Substitution of noncontact heat exchangers for direct contact water cooling
- Use of nonaqueous quench media
- Recycle of process water
- Reuse of process water as a make-up to evaporative cooling towers
- Use of process water to produce low pressure steam by noncontact heat exchange
- Recovery of spent acids or caustic solution for reuse
- Recovery and reuse of spent catalysts
- Use of nonaqueous solvents for extraction products.

End-of-pipe technology for NSPS is defined as biological treatment with suspended solids removal via clarification, sedimentation, and sand or dual-media filtration. In addition, exemplary in-process controls, as previously enumerated, are also assumed to be applicable, particularly where biotoxic pollutants must be controlled.

Costs

A summary of the costs to the organic chemicals industry associated with the implementation of regulatory provisions is given in Table W4.1.2.

Table W4.1.2. Organic chemicals industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	2147.31	89.47	89.47	120.79
BAT	0.0	0.0	0.0	115.07	1035.64
NEW PLANTS (NSPS)	254.23	902.49	711.38	1596.64	3864.85
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	254.23	3049.80	800.85	1801.19	5021.28
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	294.08	605.80	882.24	1764.47	2938.44
BAT	0.0	0.0	0.0	15.13	469.00
NEW PLANTS (NSPS)	212.18	340.06	538.59	1402.13	4108.58
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	506.26	945.86	1420.82	3181.74	7516.01
O + M					
EXISTING PLANTS					
BPT	135.98	280.12	407.95	815.90	1169.45
BAT	0.0	0.0	0.0	5.97	185.00
NEW PLANTS (NSPS)	117.71	190.27	299.35	776.17	2263.15
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	253.70	470.40	707.30	1598.04	3617.60
ANNUAL CAPITAL + O+M	759.96	1416.26	2128.12	4779.77	11133.61
ALL ANNUAL COSTS´	759.96	1416.26	2128.12	4779.77	11133.61

Chapter W4.2 Inorganic Chemicals

Regulations

The inorganic chemicals industry is a large and complex industry which is covered by numerous regulations. The industry as defined by EPA includes 63 chemical product subcategories of which 44 are covered by some level of effluent control regulations. The level of regulation for each subcategory can vary from BPT only to a full set of BPT, BAT, NSPS, PSES, and PSNS regulations. BCT limitations have been set equal to BPT (FR 47, 120) and will not generate additional costs. While regulations exist for 44 subcategories, the specific regulations will not generate costs in all cases as control requirements may be minor.

The inorganics chemicals industry has been covered in previous Cost of Clean reports. It has received major attention in this edition because of the potential magnitude of costs and the extensive amount of revisions that have occurred in the regulations. The regulations are too extensive to be summarized in this chapter and interested readers are referred to the Federal Register, Vol. 45, No. 144, January 24, 1980, p. 49450-49501 and Vol. 47, No. 125, June 29, 1982, p. 28260-28303 for current information on revisions and regulatory status.

Industry Characteristics

The inorganic chemicals industry comprises establishments that process ores or other chemicals through refining or purifying into useful inorganic chemical products. Most of the establishments are included in one of four major Standard Industrial Classification groups:

SIC 2812: Alkalies and Chlorines
SIC 2813: Industrial Gases
SIC 2816: Inorganic Pigments
SIC 2819: Industrial Inorganic Chemicals, Not Elsewhere Classified (N.E.C.)

In 1977, these industries included 1,281 establishments that shipped $12.8 billion of inorganic and related chemical products. Employment in 1977 for these establishments was over 109,000 with an average of 85 employees per plant. The highest share of the establishments (44%), shipments (67%), and employment (71%) is accounted for by the SIC 2819 group, Industrial Inorganic Chemicals N.E.C. which encompass a large number of the specific inorganic chemical products, many of which are covered by the regulatory subcategories.

Some of the major products for the industry and their 1977 value of shipments are listed below:

Product (SIC group)	Value of shipments, 1977 ($ million)
Chlorine (2812)	590
Sodium hydroxide (2812)	997
Oxygen (2813)	375
Nitrogen (2813)	279
Titanium pigments (2816)	627
Chrome pigments (2816)	454
Sulfuric acid (2819)	427
Aluminum oxide (2819)	827
Potassium and sodium compounds (2819)	1,103
Phosphorus (2819)	461

It should be noted that the Department of Commerce lists over 230 inorganic chemical products as being covered by the four major SIC codes comprising the industrial inorganics industry.

Only part of the industry will be impacted by water quality regulations. However, because of the complexity and size of the industry and lack of data, it was not practical to segment the general industry characteristics into "affected" and "not affected" segments. Nonetheless, a review of Development Documents and other data suggests that between 750 and 900 plants will be required to comply with effluent regulations and indicates the general level of industry coverage of the regulations.

Inorganic chemical plants tend to be located in industrial areas. Leading states in terms of plant numbers include California, Texas, Ohio, Pennsylvania and New Jersey.

Most of the plants will tend to be direct dischargers. Of a sample of 711 plants, only 11 percent were on sewers or generated no discharge.

The industry growth has been sporadic in recent years. Depending on use and economic conditions, individual products have experienced real annual growth in the magnitude of ± 20 percent. Trends seem to suggest, however, that overall a small positive long-term growth should occur in most segments.

Capacity utilization will vary by company, plant and year reflecting wide combinations of management, marketing, and economic conditions. In 1978, the capacity utilization for the four major SIC groups ranged from 76 percent (SIC 2819) to 90 percent (SIC 2812).

Pollutants and Sources

Most of the steps involved in inorganic chemicals production will produce wastewater. Depending on the plant and manufacturing complex, these wastewaters may then be combined with wastewater from other chemical and related production or discharged separately. Water is used for cooling, process operations, scrubbing towers, product washes, waste transport and other uses; and water use for products range from zero to 17 million gallons per day.

The industry wastewaters contain a broad range of pollutants. Toxic pollutants include, but are not limited to, chromium, nickel, lead, mercury, copper, cadmium, zinc, and cyanide. Conventional pollutants, TSS and pH also occur, as do such nonconventional pollutants as COD, fluoride, iron, and ammonia. The wastewater and chemical constituents also cause additional problems such as equipment corrosion, hazardous gas generation, treatment plant malfunctions, and problems in disposing of sludges containing toxic metals.

Again sources and pollutants will vary extensively depending on the product or industry subcategory. For additional information on this subject, subcategory summaries on pollutants and sources are provided in the appendix.

Control Technologies

The EPA has recommended several distinct control and treatment technologies for potential use in the inorganic chemicals industry. These can include combinations of neutralization, precipitation, settling, clarification, flocculation, oxidation, reduction and others. While technologies are recommended, such technologies may not be required if a plant can achieve effluent limitations with the operation of alternative technologies. Specific recommended technologies for each of the affected subcategories are not presented here due to the large number of subcategories but they are summarized in the appendix.

Costing Methodology

Water pollution costs for compliance with effluent limitations, pretreatment standards and new source performance standards were estimated by one of two methods. The first used model plant costs as presented in the Development Documents and developing cost equations for each of the subcategories and regulations for which model plant costs were available. A power equation of the form $y=Ax^b$ was used where:

y = investment costs or O & M costs, and
x = plant capacity

The second used exogenous costs as presented in the Development Documents and Federal Register notices.

A detailed explanation of the costing methodology is presented in the appendix.

The resulting cost of compliance for the inorganic chemicals industry is presented in Table W4.2.1. These costs are based on the methodologies described above and data from various Development Documents, economic impact analyses, Federal Register notices, and other industry related sources.

Table W4.2.1. Inorganic chemicals

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .162E+08

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	179.69	0.0	0.0	50.68
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	23.62	73.03	70.87	141.75	234.98
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	42.93	132.16	127.10	257.01	431.65
ANNUAL CAPITAL + O+M	66.55	205.20	197.98	398.76	666.63
ALL ANNUAL COSTS	66.55	205.20	197.98	398.76	666.63

Chapter W4.3 Plastics and Synthetics

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. In 1983 EPA proposed new regulations for BPT, BAT, NSPS, PSES, and PSNS. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the plastics and synthetics industry is not reflected in the text of the chapter or the cost estimates included in Table W4.3.1. The cost estimates represent the impact of regulations as originally promulgated.

Industry Characteristics

The plastics and synthetics industry comprises 13 product subcategories in Phase I (for which the promulgated effluent guidelines and standards were revoked on August 4, 1976) and eight product subcategories in Phase II. The subcategories in Phase I include polyvinyl chloride, polyvinyl acetate, polystyrene, polypropylene, polyethylene (high-density and low-density), cellophane, rayon, acrylonitrile-butadiene-styrene (ABS) and styrene-acrylonitrile (SAN), polyester fiber, nylon 66, nylon 6, cellulose acetate, and acrylics. Those in Phase II include ethylene-vinyl acetate copolymers (EVA), polytetrafluoroethylene, polypropylene fibers, alkyds and unsaturated polyester resins, cellulose nitrate, polyamide (nylon 6/12), polyester resins (thermoplastic), and silicones. Other products covered in the Development Documents but for which there are no effluent limitations guidelines include epoxy, phenolic, melamine and urea resins, cellulose derivatives (ethyl cellulose, hydroxyethyl cellulose, methyl cellulose, and carboxymethlcellulose), polyvinylindene chloride, polyvinyl butyral, polyvinyl ethers, nitrile barrier resins, and Spandex fibers.

Production of the various resins and plastics materials involves a variety of chemical polymerization processes in which large synthetic polymers are formed from monomers. Organic fibers, such as polyester, polypropylene, the nylons, rayon, and cellulose acetate, are produced by adding a spinning process after the polymer has been produced.

Waste Sources and Pollutants

In order to set effluent limitations guidelines, the dimension of wastewater characteristics was chosen as a basis for subcategorization. The four major subcategories are defined as:

- Major Subcategory I: Low waste load (< 10 kg/metric ton), low attainable BOD_5 concentration (< 20 mg/l). Products affected: polyvinyl chloride, polyvinyl acetate, polystyrene, polyethylene, polypropylene, ethylenevinyl acetate, fluorocarbons, and polypropylene fiber.

- Major Subcategory II: High waste load (> 10 kg/metric ton), low attainable BOD_5 concentration (< 20 mg/l). Products affected: ABS/SAN, cellophane, and rayon.
- Major Subcategory III: High waste load (> 10 kg/metric ton), medium attainable BOD_5 concentration (30-75 mg/l). Products affected: polyesters, nylon 66, nylon 6, cellulose acetates, alkyd and unsaturated polyester resins, cellulose nitrate, polyamides, saturated thermoplastic polyesters, and silicones.
- Major Subcategory IV: High waste load (> 10 kg/metric ton), low treatability. Product affected: acrylics.

The main sources contributing to the total waste load are spills, leaks, and accidents. Other sources include: washdown of process vessels, area housekeeping, utility blowdown, and laboratory wastes. Waste streams from cooling towers, steam-generating facilities, and water treatment facilities are generally combined with process wastewater and then are sent to the treatment plant.

In order to define waste characteristics, the following basic parameters were used to develop guidelines for meeting BPT, BAT, and NSPS: BOD_5, COD, TSS, zinc, pH, phenolic compounds, and total chromium.

Control Technology and Costs

Waste treatment methods in the plastics and synthetics industry include the following: biological treatment, single- or double-stage aeration, adsorption, granular activated carbon systems, chemical precipitation, anaerobic processing, air stripping, chemical oxidation, foam separation, algal systems, incineration, liquid extraction, ion exchange, reverse osmosis, freeze-thaw, evaporation, electrodialysis, and in-plant controls.

BPT guidelines for existing point sources are based on the application of end-of-pipe technology, such as biological treatment for BOD reduction by activated sludge, aerated lagoons, trickling filters, aerobic-anaerobic lagoons, etc., with preliminary treatment typified by equalization, dampening of shock loadings, settling, and clarification. BPT also calls for chemical treatment for the removal of suspended solids, oils, and other elements, as well as pH control and subsequent treatment typified by clarification and polishing processes for additional BOD and suspended solids removal, and dephenolizing units for phenolic compound removal when needed. In-plant technology and other changes that may be helpful in meeting BPT include segregation of contact process wastewater from noncontact wastewaters, elimination of once through barometric condensers, control of leaks, and good housekeeping practices.

BAT standards call for the segregation of contact process waters from noncontact wastewater, maximum wastewater recycle and reuse, elimination of once-through barometric condensers, control of leaks, good housekeeping practices and end-of-pipe technology, further removal of suspended solids and other elements typified by multi-media filtration, chemical treatment, etc. Also included are further COD removal as typified by the application of adsorptive flocs, and incineration for the treatment of highly-concentrated, small-volume wastes, as well as additional biological treatment for further BOD removal when needed.

New Source Performance Standards are based on BPT and call for the maximum possible reduction of process wastewater generation and the application of multi-media filtration and chemical treatment for additional suspended solids, other element removal, and additional biological treatment for further BOD removal as needed.

Control costs are detailed in Table W4.3.1.

Table W4.3.1. Plastics and synthetics

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .209E+09

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	235.88	0.0	0.0	88.93
BAT	0.0	0.0	0.0	28.89	252.06
NEW PLANTS (NSPS)	105.97	296.04	282.69	693.74	2573.35
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	105.97	531.92	282.69	722.63	2914.33
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	31.01	93.33	93.04	186.07	312.69
BAT	0.0	0.0	0.0	3.80	115.23
NEW PLANTS (NSPS)	76.09	107.85	188.08	519.86	1892.59
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	107.10	201.18	281.12	709.73	2320.51
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	8.97	27.82	27.12	53.52	75.36
BAT	0.0	0.0	0.0	3.41	103.07
NEW PLANTS (NSPS)	34.33	48.46	84.79	234.79	819.16
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	43.30	76.28	111.91	291.72	997.58
ANNUAL CAPITAL + O+M	150.40	277.47	393.02	1001.45	3318.09
ALL ANNUAL COSTS	150.40	277.47	393.02	1001.45	3318.09

Chapter W4.4 Rubber Manufacturing

Regulations

Regulations for the control of effluents from the production of tires and inner tubes and emulsion crumb, solution crumb, and latex rubber were proposed October 1, 1973 (Federal Register, Oct. 11, 1973) and promulgated February 8, 1974 (Federal Register, Feb. 21, 1974), to become effective April 22, 1974.

Regulations for the control of small, medium and large plants producing general molded, extruded, and fabricated rubber products; reclaimed rubber; latex-dipped products; and latex foam were proposed August 9, 1974 (Federal Register, Aug. 23, 1974) and promulgated December 30, 1974 (Federal Register, Jan. 10, 1975), to become effective January 10, 1975.

Pretreatment standards for emulsion crumb rubber and solution crumb rubber were revoked, effective March 16, 1978 (Federal Register, Feb. 14, 1978).

In addition, a regulatory amendment to revoke the BAT limitations for producers of tires and inner tubes and to revise the BAT limitations for emulsion crumb rubber solution crumb rubber; latex rubber; general molded, extruded and fabricated rubber products; latex-dipped products; and latex foam was proposed on November 30, 1979 (Federal Register, December 18, 1979). The promulgated regulations as well as the proposed regulations are analyzed in this chapter.

Industry Characteristics

The rubber processing industry includes the manufacture of tires and inner tubes; synthetic rubber; general molded, extruded, and fabricated rubber products; reclaimed rubber; latex-dipped products; and latex foam.

Plants that produce tires and inner tubes are classified in SIC 3011. The typical tire manufacturing process includes the following:

- Preparation or compounding of the raw materials,
- Transformation of these compounded materials into five tire components--tire bead coating, tire treads, tire sidewall, inner liner stock, and coated cord fabric,
- Building, molding, and curing the final product.

The raw materials used include a variety of synthetic and natural rubbers; three categories of compounding materials: filler, extenders, and reinforcers (carbon black and oil are two common examples); and other chemicals that are used as antioxidants, pigments, or curing and accelerating agents. Compounding is usually carried out in a batch-type, internal mixing device called a Banbury mixer. After mixing, the compound is sheeted out in a roller mill, extruded into sheets, or pelletized. The sheeted materials are tacky and must be coated with a soapstone solution to prevent the materials from sticking together during storage. The compounded rubber stock is transformed into one of the tire components by molding, extruding, calendering, and a variety of other operations. The tire is built up as a cylinder on a collapsible, round rotating drum by applying the inner layer, then by adding layers of cord, beads, belt, and tread. Finally the "green" tire is molded and cured in an automatic press, and the excess rubber is ground off. Inner tubes are produced using the same basic processing steps.

Tire and tube products are produced in fifty-six major plants and several smaller plants in the United States. Tire plants vary widely in capacity; the largest produce approximately 30,000 tires per day, and the smallest produces less than 5,000 tires per day. In 1972, the industry produced 233 million tires and by 1981 production decreased to 195 million tires. Long-term trends indicate that future growth in production will be closely related to annual growth rates in domestic and foreign vehicle registrations which are estimated at a combined rate of 1.5 percent.

The production of synthetic rubber is classified in SIC 2822. For the purpose of establishing effluent limitations guidelines, the synthetic rubber industry was divided into three subcategories: emulsion crumb, solution crumb, and latex. Crumb rubbers, generally for tires, are sold in a solid form, and are producted through two different processes: emulsion polymerization and solution polymerization. Latex rubbers, generally for specialty products, are sold in latex form, and are produced through emulsion polymerization.

Emulsion polymerization is the traditional and dominant process for producing synthetic rubber. The raw materials (monomers) are usually styrene and butadiene, to which a catalyst, activator, and modifier are added in a soap solution to produce an emulsion in an aqueous medium; polymerization proceeds step-wise through a train of reactors. The product rubber is formed in the emulsion phase of the reaction mixture, which is a milky white emulsion called latex. Unreacted monomers are then recovered from the latex by vacuum stripping; the production process ends at this point for latex rubbers. If crumb rubber is desired, sulfuric acid and sodium chloride are added to the latex to coagulate the crumb rubber, which is then dewatered, rinsed, filtered, and finally dried with hot air to produce the final product.

The production of synthetic rubbers by solution polymerization is a step-wise processing operation very similar to emulsion polymerization. For solution polymerization, the monomers must be extremely pure, and the solvent (hexane, for example) must be completely anhydrous. The polymerization reaction is more rapid (1 to 2 hours) and is taken to over 90 percent conversion as compared to 60 percent conversion for emulsion polymerization. Both monomers and solvents are generally passed through drying columns to remove all water. After reaction, the mixture leaves the reactor as a rubber cement; i.e., polymeric rubber solids dissolved in solvent. As with emulsion polymerization, coagulation, washing, dewatering, and drying processes produce the final product.

Thirteen companies operating twenty-eight plants produce most of the crumb synthetic rubber in the United States. Most of these plants are part of diversified complexes that produce other products, such as rubber processing chemicals, plastics, and basic intermediate organic chemicals. Latex is produced by seventeen plants owned by eight companies, three of which are not included in the preceding listing.

Annual production of synthetic rubber increased from 2.45 million metric tons in 1972 to a peak of 2.72 million metric tons in 1979. Production dropped to 2.15 million metric tons in 1980 and has begun to recover in 1981 on the uptick of a cyclical growth pattern. The industry will continue to follow short-term cyclical production patterns and long-term growth is projected at an annual rate of one percent.

General molded, extruded, and fabricated rubber products include such disparate items as rubber footwear (SIC 3021), rubber hose and belting (SIC 3041), fabricated rubber products not elsewhere classified (SIC 3069), and rubber gaskets, packings, and sealing devices (SIC 3293). The manufacturing processes for these rubber products include compounding of the rubber stocks, then forming of the compounded stock by a variety of means, such as molding, extrusion, lay-up, or other fabrication means.

There are approximately 1,355 plants in this subcategory with the largest number in SIC 3069, fabricated rubber plants not elsewhere classified. The value of shipments from plants in SIC 3069 has increased at an annual adjusted rate of 1.7 percent (in 1972 dollars) and the growth rate is expected to increase to a 2.4 percent annual rate reflecting growing manifests, including the automotive markets. Competition from foreign products has severely hampered the growth in domestic manufacturing establishments classified in SIC 3021 as evidenced by the decline in domestic product shipments from $500 million in 1972 to $300 million in 1981. No significant changes are projected and future levels of shipments should remain constant. The value of shipments from firms producing hoses and belting (SIC 4031) has increased at an annual rate of .9 percent from 1972 to 1978 and is projected to increase with economic activity at an annual rate of 3.5 percent. Firms producing products classified in SIC 3293 (rubber gaskets, packings and sealing devices) experienced a 2.2 percent adjusted annual growth in value of shipment from 1972 to 1979 and this annual growth rate is projected for the future.

Reclaimed rubber is classified in SIC 3031, although some of the establishments in which rubber is reclaimed may be classified in SIC 3011--Tires and Inner Tubes. The promulgated regulation specified two subcategories of this industry--(1) wet digestion and (2) pan, dry digestion or mechanical. Scrap separation and size reduction steps are common to all reclaim rubber processes. In wet digestion processes, the ground rubber is partially depolymerized by heating with reclaiming agents and water in an autoclave, followed by digestion with defibering agents to remove fibers. In the pan process, the ground rubber scrap is further reduced in size and defibered by additional grinding. It is blended with reclaiming oils and heated in open pans in a pressure vessel. In the continuous mechanical process, the finely ground, fiber-free scrap is fed continuously into a heated, high-shear screw machine in the presence of reclaiming agents and depolymerization agents. The reclaimed products are shipped in slabs or bales.

The annual adjusted value of shipments from the eleven reclaimed rubber plants in the U.S. has declined from about $30 million in 1972 to $20 million in 1981. Future production in the industry is projected to remain constant at the 1981 level.

Latex-based products are included in SIC 3069, Fabricated Rubber Products not Elsewhere Classified, and in SIC 3021, Rubber and Plastics Footwear. There are approximately eighty-four plants in the U.S. producing latex-dipped, extruded and molded rubber products and zero plants producing latex foam products.

Pollutants and Sources

The pollutants or pollutant properties controlled by effluent guidelines and standards for the rubber processing industry are presented in Table W4.4.1. The major sources of the regulated pollutant are also included. Certain pollutants are contributed by dischargers unrelated to the primary production operations. These nonprocess effluents result from utility and water treatment discharges, and from domestic wastewater discharge generated within the plant boundaries. These nonprocess related dischargers are not regulated by effluent guidelines and standards. However, when process and nonprocess effluents are combined, nonprocess related pollutants may contribute to the quantity or quality of pollutants or pollutant properties controlled by effluent guidelines and standards. The major process wastewater streams of the subcategories of the rubber processing industry are summarized below:

The primary water usage in the tire and inner tube industry is for noncontact cooling and heating. The process wastewaters consist of mill area oily waters, soapstone slurry and latex dip wastes, area washdown waters, emission scrubber waters, and contaminated storm waters from raw material storage areas, etc. For the purposes of establishing effluent limitations guidelines for manufacturers of tires and inner tubes, the following pollutant parameters have been designated as significant: suspended solids, oil and grease, and pH.

The principal waste streams from synthetic rubber manufacture are steam and condensate from the monomer recovery stripping operation, overflow of coagulation liquors, and overflow of the crumb rubber rinse waters. Area washdown and equipment clean-out wastewaters are also major sources of pollutants, particularly in latex rubber plants where cleanup is more frequent because of smaller production runs. For manufacturers of synthetic rubbers, the following pollutant parameters have been designated as significant: chemical oxygen demand, biochemical oxygen demand, suspended solids, oil and grease, and pH.

Table W4.4.1. Pollutants and sources

Subcategory	Pollutant a/	Source
A. Tires and inner tubes	TSS	• Washdown and runoff from compounding areas • Discharges of soapstone solution • Nonprocess boiler blowdowns • Water treatment wastes
	Oil and grease	• Washdown, runoff, spills, and leakage in process areas which pick up lubricating and extender oils
	pH	• Process wastewaters
Synthetic Rubber Industries:	COD	• Organic compounds which contact process wastewater
B. Emulsion crumb rubber	BOD_5	• Organic compounds which contact process wastewater
C. Solution crumb rubber D. Latex rubber	TSS	• Uncoagulated rubber (emulsion crumb and latex rubber subcategories • Rubber crumb fines (emulsion crumb and solution crumb subcategories
	Oil and grease	• Insoluble monomers • Solvents and extender oils (emulsion crumb and solution crumb subcategories) • Miscellaneous machinery and hydraulic oils
	pH	• Acidic coagulation liquors (emulsion crumb subcategory) • Strong caustic soda solutions bled into effluent where monomer inhibitors are removed
General Molded, Extruded and Fabricated Rubber Products E. Small F. Medium	TSS	• Washdown and runoff from compounding areas • Discharge from anti-tack solutions • Nonprocess boiler blowdowns • Water treatment wastes
G. Large	Oil and grease	• Washdown, runoff, spills, and leakage in process areas which pick up lubricating, process, and fuel oils
	pH	• Process wastewaters
	Lead	• Vulcanizer condensate and contact cooling waters from hose production facilities using a lead sheath cure
Reclaimed Rubber H. Wet digestion	COD	• Dewatering wastewaters (wet digestion subcategory) • Condensed vapor streams for depolymerization • Anti-tack solutions • Oil and grease
I. Pan, dry digestion, and mechanical	TSS	• Washdown and runoff from compounding areas • Dischargers of anti-tack solutions • Nonprocess boiler blowdowns • Water treatment works • Dewatering liquor when fibrous stock is fed to digesters (wet digestion subcategory)

Continued ...

Table W4.4.1. (Continued)

Subcategory	Pollutant a/	Source
	Oil and grease	• Digester process oil in dewatering liquor (wet digestion subcategory) • Organics scrubbed from vapor streams • Lubricating oil leakage
	pH	• Dependent on formula used in wet digestion
Latex Based Products	BOD5	• Organic compounds which contact process wastewater (dependent on product washing technique employed)
J. Latex dipped, extruded and molded rubber	TSS	• Uncoagulated latex from washdown and clean out waste
K. Latex foam	pH	• pH adjustment made in process wastewaters for chemical coagulation treatment process
	Chromium	• When chromic acid is used in form-cleaning solution (latex dipped, extruded and molded rubber subcategory)
	Zinc	• Foam wash waters when zinc is used (latex foam subcategory)

a/ Pollutants listed include only those regulated by effluent limitations guidelines and standards.

Source: Development Documents EPA-440/1-74-013-a, pp. 65-81 and EPA-440/1-74-030-a, pp. 91-116.

The major process wastewater streams from the production of general molded, extruded, and fabricated rubber products are spills, leakage and washdown, from processing areas, and runoff, from outdoor storage areas; vulcanizer condensate and contact cooling water from the curing of lead-sheathed and cloth-wrapped hoses; and vulcanizer condensate from the curing of cement dipper items. Process wastewaters evolved from sources within the general molded, extruded, and fabricated rubber plants subcategories are to be treated for suspended solids (TSS), oil and grease, lead (from lead-sheathed hose production) and pH.

The primary sources of process wastewater streams for the reclaimed rubber industry are dewatering liquor and defibering scraps from the wet digester process; spills, leaks and washdown from processing areas; and vapor condensate collected by air pollution control devices. The effluent guidelines and standards for the reclaimed rubber subcategories have designated chemical oxygen demand (COD), suspended solids (TSS), oil and grease, and pH as the contaminated constituents to be controlled.

The major wastewater streams from the production of latex based products are product washwaters (which will contain zinc when zinc oxide is used in late foam manufacture); spills, leaks, washdown and run-off from latex storage, compounding and transfer areas; discharges from foam cleaning operations. The effluent guidelines and standards for the latex based products subcategories regulate the quantity or qualities of biological oxygen demand (BOD5), suspended solids (TSS), pH, chromium (from chromic acid cleaning operations), and zinc (from zinc oxide curing).

Control Technology

Various control technologies used to meet BPT, and NSPS were recommended and costed in the rubber processing industry's Development Documents. Various control technologies were also recommended to meet pretreatment standards for new sources but were not costed. Existing source pretreatment standards have not yet been promulgated and all of the BAT limitations are less than or equal to BPT. The recommended technologies for this industry are summarized below:

BPT, NSPS. The technologies recommended to meet BPT regulations, and NSPS consist of:

- Elimination of any discharge of soapstone solution by:
  - Recycling soapstone solution;
  - Installation of curbing and sealing drains around the soapstone dipping area; and
  - Reuse of recirculating system washwater as makeup for fresh soapstone solution.
- Elimination of any discharge of latex solution by:
  - Installation of curbing and sealing drains around the latex dipping area; and
  - Containment of all wastewaters in the area.

- Segregation, control and treatment of all oily waste streams by:
  - Isolation of process wastewaters from nonprocess wastewaters;
  - Treatment of process wastewaters with API-type gravity separation; and
  - Additional treatment through an absorbant filter.

The control and treatment technology recommended to meet BPT and NSPS guidelines for emulsion crumb and latex plants is chemical coagulation and clarification; biological treatment by activated sludge processes; improved housekeeping and maintenance practices; and in-plant modifications for crumb plants such as the use of crumb pits to remove crumb rubber fines from coagulation liquor and crumb rinse overflows.

Because solution crumb wastewaters do not contain uncoagulated latex solids, the chemical coagulation step is not necessary. BPT and NSPS technology for solution crumb plants have been defined as comparable to primary clarification and biological treatment, with the use of crumb pits to catch crumb rubber fines before treatment.

The control and treatment technology recommended for general molded, extruded, and fabricated products plants to meet BPT and NSPS guidelines consists of eliminating anti-tack or latex solution discharge and isolation, control, and treatment of all oily waste streams. The discharge of anti-tack and latex solutions can be eliminated by recycling of soapstone solution, installation of curbing around the soapstone dipping area and latex storage and transfer areas, sealing of drains in the dipping area and latex use areas, reuse of the recirculating system wash water as makeup for fresh soapstone solution, and the containment of all latex-contaminated waste streams. Control and treatment of oily waste streams involves segregation, collection, and treatment of runoff from oil storage and unloading areas and leakage and spills in the process areas.

For plants manufacturing hose via lead-sheathed processes additional control technology for the control of lead is required. The recommended treatment for lead is accomplished by segregation and precoat filtration and lead-laden waste water.

None of the wet-digestion reclaim rubber plants discharge directly, and no new plants will use the wet-digestion process.

Waste from the pan, mechanical, and dry digestion reclaim processes are comparable to those from the general molded rubber plants. The technology recommended for meeting BPT and NSPS guidelines includes eliminating anti-tack solution discharge and segregation, control, and treatment of all oily waste.

The control and treatment technology recommended for latex-dipped products to meet BPT, BAT and NSPS guidelines includes chemical stream segregation of process wastewater from nonprocess wastewater; coagulation and clarification; and biological treatment of the clarified waste stream in an aerated lagoon and subsequent settling and removal of the settled solids. Additional control and treatment techniques are required for latex dipping operations which use chromic acid as a form cleaning agent. These wastes can be eliminated by use of alternative cleaning techniques. If the chromic acid cleaning technique cannot be replaced, chemical precipitation and sedimentation is required.

PSNS. For latex foam, the technologies recommended to meet BPT and NSPS guidelines include chemical coagulation and clarification of latex-bearing wastewaters and chemical precipitation of zinc from the rinse waters. The clarified wastewaters from these two streams are combined in a neutralization tank and the pH is adjusted to a level suitable for biological treatment.

A minimum level of pretreatment must be given to wastewaters that will be discharged from new production facilities to publicly owned treatment works, and pollutants which would inhibit or upset the performance of such treatment works must be eliminated. Pretreatment recommendations for process wastewaters from the tire and inner tube industry include the separation of oils and solids in an API gravity separator and the use of an equalization basin to prevent shock loads of oil, suspended solids, or batch dumps of dipping solutions. For nonprocess wastewaters, such problems as acidity, alkalinity, solids, oils, and heavy metals may require control at the plant to conform to local ordinances for discharge to publicly owned treatment works.

Pretreatment standards for emulsion crumb rubber and solution crumb rubber were revoked February 14, 1978. The pretreatment requirements for wastewater discharges to publicly owned waterworks from latex rubber plants are chemical coagulation of latex-laden wastewaters and neutralization or equalization of utility wastes.

Pretreatment recommendations for process wastewaters from facilities producing molded, extruded, and fabricated rubber products including latex-dipped products and latex foam; wet-digestion reclaimed rubber; and pan, mechanical, and dry digestion reclaimed rubber include the separation of oils and solids in an API gravity separator, and the use of an equalization basin to prevent shock loads of oil, suspended solids, or batch dumps of dipping solution from upsetting the performance of treatment works. In addition, lead-laden wastewaters from general rubber products, latex-laden wastewater from latex-based products, chromium from latex-dipped products, and zinc from latex foam products must be treated. If fibers are digested with rubber scrap, a large sedimentation lagoon may be required.

Costing Methodology

Waste pollution control costs to the rubber processing industry for compliance with effluent limitations, pretreatment standards, and new source performance standards were presented by EPA in the two Development Documents for the rubber processing industry. These costs were developed for one plant of typical size for each of the industry subcategories. This analysis used these costs and typical plants to derive cost regulations and the total capital and O&M costs of the regulations. These costs of compliance for the rubber industry are presented in Table W4.4.2.

Table W4.4.2. Rubber manufacturing

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

	BASE	1978	1983	1988	
CAPACITY: IN: 1000MT/YEAR	.105E+05	.102E+05	.106E+05	.115E+05	
CAPITAL IN PLACE (KIP):	.299E+09				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	135.19	0.0	0.0	61.54
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	7.96	13.55	13.14	38.03	91.40
PSES/PRETREAT	0.0	66.94	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	12.86
TOTAL	7.96	215.68	13.14	38.03	165.80
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	17.66	65.04	52.98	105.96	175.62
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	3.50	3.09	8.07	25.05	86.27
PSES/PRETREAT	8.80	26.40	26.40	52.81	88.01
PSNS	0.0	0.0	0.0	0.0	3.33
TOTAL	29.96	94.54	87.46	183.81	353.22
O + M					
EXISTING PLANTS					
BPT	11.85	40.21	35.35	71.21	120.51
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	4.42	4.34	10.36	31.25	104.30
PSES/PRETREAT	8.25	22.66	24.26	50.16	90.29
PSNS	0.0	0.0	0.0	0.0	4.74
TOTAL	24.52	67.21	69.96	152.62	319.85
ANNUAL CAPITAL + O+M	54.48	161.75	157.42	336.44	673.06
USER CHARGES	0.00	0.00	0.00	0.00	0.00
ALL ANNUAL COSTS	54.48	161.75	157.42	336.44	673.06

Chapter W4.5 Soap and Detergent Industry

Regulations

The costs included in this chapter are for BPT, BAT and NSPS regulations promulgated in 1974 and 1975. Little regulatory activity has occurred since that time. This industry has been exempted from additional federal guidelines under Paragraph 8 of the 1976 settlement agreement with NRDC.

Industry Characteristics

Soap and detergent industry establishments are engaged in the manufacture of soap, synthetic organic detergents, inorganic alkaline detergents, or any combination of these processes. The term "soap" refers to those cleaning agents which are derivatives of natural fat. The term "detergent" is generally restricted to cleaning compounds derived largely from petrochemicals.

Soaps and detergents are produced by a variety of manufacturing processes. For the purpose of establishing effluent limitation guidelines and standards of performance the industry has been divided into 19 subcategories based on processes and products:

Soap Manufacture

- Soap Manufacture--Batch Kettle and Continuous
- Fatty Acid Manufacture by Fat Splitting
- Soap from Fatty Acid Neutralization
- Glycerine Recovery
- Glycerine Concentration
- Glycerine Distillation
- Soap Flakes and Powders
- Bar Soaps
- Liquid Soap

Detergent Manufacture

- Oleum Sulfonation and Sulfation (Batch and Continuous)
- Air- Sulfur Trioxide Sulfation and Sulfonation (Batch and Continuous)
- Sulfur Trioxide Solvent and Vacuum Sulfonation
- Sulfamic Acid Sulfation
- Chlorosulfonic Acid Sulfation
- Neutralization of Sulfuric Acid Esters and Sulfonic Acids
- Spray Dried Detergents
- Liquid Detergent Manufacture
- Detergent Manufacturing by Dry Blending

- Drum Dried Detergents
- Detergent Bars and Cakes

The leading products for each class are toilet bars in the soap segment and laundry detergents in the detergent segment. Household laundry detergents also account for a large percent of the total value of shipments of soaps and detergents made by all industries.

The largest fraction of the industry's establishments, approximately one-third, is located in the North Central region of the United States. Although there are a large number of producers, the soap and detergent industry is an oligopolistic industry. About 2 percent of the establishments account for 47 percent of the industry's value of shipments, 5 percent account for 69 percent of the industry's value of shipments. The "big three" companies in the soap and detergent industry are Proctor & Gamble, Lever Brothers, and Colgate-Palmolive.

Production has been maintaining a 4.6 percent growth, and is expected to continue.

Pollutants and Sources

The manufacturing of soaps and detergents represents a minor source of water pollution. Approximately 98 percent of the plant effluents go to municipal treatment plants with the remaining 2 percent of the industry discharging as point sources. Raw waste loads from the soap and detergent manufacturing process vary considerably.

The processes that are heavy effluent generators are: (1) batch kettle, (2) fatty acid manufacturing by fat splitting and distillation, (3) glycerine recovery, (4) bar soap manufacture, (5) spray drying of detergents, and (6) manufacture of liquid detergents. The major pollution sources for these processes are: washout of equipment, leaks and spills, discharge of barometric condenser water, cooling tower blowdown, and discharge of scrubber waters from air pollution control equipment. Constituents of these wastewater streams are fats, fatty acids, glycerine, oil and grease, salts, lye, and the soap or detergent produced in the plant.

The other processes are able to recycle their wastewater or use a dry cleanup process. Therefore, they have virtually no water pollutants.

The pollutants covered by the effluent limitations guidelines for the soap and detergent industry are BOD_5, COD, suspended solids, surfactants, oil and grease, and pH.

Control Technology and Costs

The largest reductions in the pollution load from this industry can be made through lower process water usage. One of the biggest improvements would be either changing the operating techniques associated with the barometric condensers or replacing them entirely with surface condensers. Large reductions in water usage in the manufacture of liquid detergents could be achieved through the installation of additional water recycling, and by the use of air rather than water to blow out filling lines.

BPT guidelines call for plants to adopt good housekeeping procedures, adopt recycling where appropriate, and install biological secondary treatment (bioconversion). BAT guidelines assume improvement in manufacturing processes such as the replacement of barometric condensers by surface condensors, installation of tandem-chilled water scrubbers (for spray-dried detergents), and the use of a batch counter current process in air-sulfur trioxide sulfation and sulfonation. In addition, improvements in end-of-pipe treatment are expected including the addition of sand or mixed-media filtration or the installation of a two-stage, activated sludge process. New source performance standards are the same as BAT for most product subcategories. Improvements over the old BAT requirement are expected as some plants are installing new, lower polluting processes, such as continuous processes instead of batch processes.

Since approximately 98 percent of the soap and detergent manufacturers discharge into municipal sewers, the total cost to the industry of meeting these guidelines is low. For the purpose of estimating annualized control costs, three model plants were created. These models contain principally those processes to be heavily impacted by the effluent guidelines recommendations. The models are:

(1) A small soap company
(2) A small liquid detergent company
(3) A very large integrated soap and detergent company.

The control costs for the industry are shown in Table W4.5.1. These costs represent the situation as determined by consultation with cognizant EPA staff as of February, 1982.

Table W4.5.1. Soap and detergent industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .285E+06

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	4.03	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.51	0.68
NEW PLANTS (NSPS)	0.34	1.35	0.97	2.07	4.51
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.34	5.38	0.97	2.59	5.20
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.53	1.06	1.59	3.18	5.30
BAT	0.0	0.0	0.0	0.13	0.67
NEW PLANTS (NSPS)	0.30	0.52	0.78	1.98	5.38
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.83	1.58	2.37	5.29	11.35
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.25	0.51	0.76	1.53	2.54
BAT	0.0	0.0	0.0	0.06	0.30
NEW PLANTS (NSPS)	0.14	0.25	0.37	0.94	2.57
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.40	0.75	1.14	2.53	5.42
ANNUAL CAPITAL + O+M	1.23	2.33	3.51	7.82	16.76
ALL ANNUAL COSTS	1.23	2.33	3.51	7.82	16.76

Chapter W4.6 Carbon Black Industry

Costs in this report are based on nine non-conforming plants (38.6 percent of industry capacity) of a total population of 30 plants. The other plants were in conformance with EPA water regulations before the regulations were promulgated.

Regulations

On January 9, 1978, the proposed guidelines for BAT, NSPS, and pretreatment for this industry were promulgated without modifications, and BPT regulations for the furnace process were withdrawn. Most of the plants were in compliance before the regulations were promulgated. The withdrawal of the BPT regulations effectively gave the remaining 9 furnace plants until July 1, 1983 to achieve no discharge of wastewater pollutants.

Industry Characteristics

Carbon black is a black, fluffy, finely divided powder consisting of 90 to 99 percent elemental carbon. Carbon black is uniquely different from other bulk carbons, such as charcoals and cokes, both in terms of properties and applications. Although there are many different grades of carbon black, it is generally treated as a single product.

In essence, carbon black is manufactured by producing carbon from either liquid or gaseous hydrocarbon materials. Depending upon the process, the production is achieved either by thermal degradation or incomplete combustion. In the United States, four different manufacturing processes have been employed, including the furnace, thermal, channel, and lampblack processes. The furnace process accounts for about 95 percent of U.S. production, the thermal process about 5 percent, and the lampblack process for a very small fraction. The last U.S. channel carbon black plant closed in 1976.

Seven companies operate 30 furnace black plants, two of which also contain facilities for the production of thermal black. The capacities of these 30 plants range from 23,000 to 130,000 metric tons per year. In addition, two small plants produce lampblack, one small plant produces bone black, and one small plant produces acetylene black. All establishments producing furnace or thermal black are classified in SIC 2895. This establishment classification accounts for about 99 percent of all U.S. carbon black production.

The major end uses of carbon black are in the manufacture of rubber, printing ink, paint, paper, and plastics. Typically, more than 93 percent of total carbon black consumption is in rubber applications, and the rubber tire industry is by far the principal consumer. Printing ink represents the second largest use of carbon black. The United States is a net exporter of carbon black (typically 5 percent of total production). Recently installed overseas production capacity has resulted in a trend toward shrinking U.S. exports, however.

The U.S. production of carbon black has fluctuated considerably since 1967. Average growth in the period 1967 to 1978 was 1.85 percent per year. The various pressures on the automotive industry are expected to reduce future growth of the carbon black industry to about 1.6 percent per year. U.S. carbon black production was 1.497 million metric tons in 1978 and should be about 1.755 million metric tons in 1988.

Pollutants and Sources

The thermal black process produces an inherent process wastewater stream. It consists of recirculating cooling-water purge contaminated with carbon black. In the thermal black process, furnace gas is quenched with water to reduce its temperature before it is passed through bag filters where the product carbon is removed. The hydrogen-containing exit gas thus contains an appreciable amount of water vapor, which must be removed before recycling the hydrogen back into the process as fuel. The water vapor in the gas stream is removed by cooling the gas stream with water sprays, thus lowering the gas temperature below the boiling point of water and thereby condensing out most of the moisture. The spent spray water undergoes a temperature rise caused by the liberated heat of condensation and must, therefore, be cooled prior to reuse. Typically, the spray water is part of a cooling water circuit in which fresh makeup water is added to replenish inevitable losses within the system. As with most cooling circuits, it is necessary to purge or "blow down" a certain fraction of the total circulation to prevent the buildup of undesirable contaminants. In the thermal black process, this blowdown stream is contaminated with small amounts of carbon black lost from the process. Thermal black plants may eliminate this blowdown stream by using it to quench the hot gases leaving the furnaces. Otherwise, the purge stream forms a point-source discharge. The two thermal black plants still in operation are located on the same sites as two furnace black plants, and had achieved no discharge of process wastewater contaminants by 1976. No further consideration will be given to thermal plants.

Carbon black manufacturing plants employing the furnace black process do not produce an inherent process wastewater stream. Certain furnace black plants, however, do have small plant washdown streams and stormwater runoff streams. The local rainfall/evaporation relationship plays a large role in determining whether there is, or is not, a point-source discharge from the plant. Of a total of 30 furnace black plants, 21 do not have point-source discharges. Some plants have no discharge primarily because of favorable climate conditions, while others are able to use excess water as quench water. Nine furnace black plants were found to discharge process wastewaters in 1976, whereas the remaining furnace plants had no discharge.

Control Technology

The control technologies recommended and costed by EPA in the Development Document consist of two wastewater treatment steps: Step 1 consists of sedimentation and Step 2 consists of filtration. It is anticipated that certain plants will require only Step 1, while other plants will require both Step 1 and Step 2. In any case, the cost model provides for the treated effluent to be totally recycled back to the process. This treatment is intended to reduce the discharge of total suspended solids (TSS) from an average of 0.97 kg/metric ton of product to zero.

Costing Methodology

Water-pollution control costs are given in 1974 dollars in the EPA Economic Analysis of the Carbon Black Industry for a thermal black plant having a capacity of 214 metric tons per day (74,900 metric tons per year). The capital cost is given as $279,900 and annual operating and maintenance costs as $11,200 for control involving both sedimentation and filtration. Costs were applied to the nine plants that were discharging process wastewaters in 1976. The average capacity of these plants is 77,800 metric tons per year. In 1974 dollars, the investment cost averages $286,350 per plant, or total investment costs are $2,577,150. The annual operating and maintenance cost is $11,640 per plant, or $104,760 for all nine plants.

The BPT regulation was withdrawn in 1978 for these plants, although one plant was scheduled to be in compliance by July 1, 1977. It is estimated that about 50 percent of these plants will have made their investments by 1981 and the remaining 50 percent by 1983.

The costs estimated on the above basis are given in Table W4.6.1. As stated above these costs are based on achievement of zero discharge by nine plants.

Table W4.6.1. Carbon black industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.43	0.85	1.28	3.41	2.56
NEW PLANTS (NSPS)	0.07	0.08	0.22	0.44	0.76
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.50	0.93	1.50	3.85	3.32
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.28	0.17	0.67	2.21	5.18
NEW PLANTS (NSPS)	0.04	0.01	0.09	0.26	0.84
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.32	0.18	0.76	2.48	6.02
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.07	0.04	0.17	0.57	1.34
NEW PLANTS (NSPS)	0.01	0.00	0.03	0.08	0.26
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.08	0.05	0.20	0.65	1.60
ANNUAL CAPITAL + O+M	0.40	0.23	0.96	3.13	7.62
ALL ANNUAL COSTS	0.40	0.23	0.96	3.13	7.62

Chapter W4.7 Explosives Industry

Regulations

Effluent limitations were established for this industry in 1976 for BPT and BAT. The non-military sector of this industry was exempted under Paragraph 8 of the 1976 settlement agreement with the Natural Resources Defense Council. This sector will not be affected by any national effluent limitations other than the BPT.

Industry Characteristics

The U.S. explosives industry includes over 600 plants. Explosives plants generally are evenly distributed in the eastern portion of the United States, away from large population centers. Plant sites range from a few hundred to several thousand acres. The general production process for the manufacture of explosives involves the nitration of an organic molecule, such as glycerine, toluene and cellulose. Raw materials used in this process are nitric acid, acting as a nitrate source, and sulfuric or acetic acid, acting as a dehydrating agent. Nitration products include nitroglycerin, dinitroglycerin, trinitrotoluene, dinitrotoluene, trinitroresorcinol, nitromannite, and nitrocellulose.

For the purpose of establishing effluent limitations guidelines, the explosives industry has been divided into the following four subcategories based upon the raw material used and the process employed:

- Explosives - Category A
- Propellants - Category B
- Load, Assemble, and Pack plants (LAP) - Category C
- Initiating-Compound Plants - Category D.

Pollutants and Sources

The wastewater sources associated with each subcategory are presented in the following sections.

Manufacture of Explosives. The wastes from this category are characteristically high in BOD_5, COD, nitrates, sulfates, and TOC. Highly variable pH is also characteristic of the wastewater from the explosive industry. The major waste loads generally come from the finishing area where the crude explosive becomes the finished product.

Manufacture of Propellants. The waste loads associated with the manufacture of propellants are usually higher than those associated with the manufacture of explosives. Suspended solids are a troublesome problem, especially in the manufacture of nitrocellulose. Wide variation in pH is also a problem. High BOD_5, COD, and TOC levels can be attributed to the organic compounds and solvents involved in the processes, while high nitrate and sulfates can be attributed to the use of nitric acids and sulfuric acids, respectively.

Load, Assemble, and Pack Plants. Waste loads from this category are the mildest in the explosive industry but the most variable. BOD_5, COD, nitrates, sulfates, TOC, and TSS are in the effluent waste loads.

Initiating-Compound Plants. The waste loads associated with the manufacture of initiating compounds are the highest of any category in the explosives industry, due to the highly concentrated waste streams and small volumes of production. Because of the small quantities, batch processes are used in this category and recovery of spent materials is not attempted. Waste loads are high in the following parameters: BOD_5, COD, nitrates, sulfates, TOC, TSS, and TKN (Total Kjeldahl Nitrogen).

For the purpose of establishing effluent guidelines for the explosives industry the following parameters have been defined to be of major significance: BOD_5, COD, TSS, pH, and oil and grease.

Control Technology and Costs

The technology for the control and treatment of waterborne pollutants in the explosives industry can be divided into two broad categories: in-process and end-of-pipe. In-process depends on two major conditions.

- Altering the processes that generate water pollutants
- Controlling water use in non-process as well as process areas.

Specific in-process control practices applicable to the explosives industry include good water management, which, with recycling of process cooling water, can have a significant effect on hydraulic loading and would reduce treatment costs. Separation of process and noncontact waters is a first step in economical pollution abatement. Prior to end-of-pipe treatment, the following plant control measures will be mandatory: neutralization facilities, catch tanks on finishing explosive lines, and other pretreatment facilities.

The recommended technology for achieving BPT guidelines relies upon the use of an activated sludge treatment plant for Categories A, B, and D. For Category C an extended aeration package system was recommended. Also, since many of the waste streams have extreme pH values, neutralization is necessary.

Costs for this industry are summarized in Table 4.7.1.

Table 4.7.1. Explosives industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	1201.81	0.0	0.0	0.0
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	158.01	476.59	474.92	948.05	1518.52
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	78.04	235.29	234.12	468.24	780.40
ANNUAL CAPITAL + O+M	236.05	711.88	708.14	1416.29	2298.92
ALL ANNUAL COSTS	236.05	711.88	708.14	1416.29	2298.92

Chapter W4.8. Pesticides and Agricultural Chemicals

Regulations

Regulations affection this industry were revised under the provisions of the NRDC Consent Decree. In November 1982 EPA proposed regulations for BCT, BAT, NSPS, PSES, PSNS, and expanded BPT to include active ingredients which were excluded from the original BPT regulations. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the pesticides and agricultural chemicals industry is not reflected in the text of the chapter or the cost estimates included in Table W4.8.3. The cost estimates represent the impact of the regulations as originally promulgated.

Industry Characteristics

The pesticide chemicals manufacturing industry is classified under SIC 2879 and has been subdivided for pollution control purposes into six subcategories. Five of these relate to the type of product, and the sixth to a specialty operation concerned with formulating and packaging. The subcategories are as follows:

- Subcategory A--Halogenated organics production
- Subcategory B--Organo-phosphorus production
- Subcategory C--Organo-nitrogen production
- Subcategory D--Metallo-organic production
- Subcategory E--Formulation and packaging
- Subcategory F--Miscellaneous pesticides not otherwise classified.

The products of the pesticide industry have generally been divided into three basic classes--herbicides, fungicides, and insecticides. The largest group in terms of value is the herbicides.

The products of this industry are highly varied and over 400 have been identified according to the various subcategories. Note that separate, more strict standards have been enacted for several pesticides as toxic pollutants.

The chemistry involved in the production of pesticides is highly varied and complex, so that many different chemical operations are used. In addition, the plants which formulate rather than produce the pesticides usually employ a number of operations. The five production subcategories are discussed below.

Halogenated Organic Compounds. Ninety-eight products were identified in this subcategory. These have been further broken down into five groups, and are related to their major use as shown in Table W4.8.1.

Table W4.8-1. Halogenated organic pesticide groupings and use

Group	Compound	Use
A1	DDT*	Insecticide
	Dithiocarbamates	Fungicide
	Methoxychlor	Insecticide
A2	2.4-D	Herbicide
	2.4.5-T*	Herbicide
	MCPA	Herbicide
A3	Toxaphene	Insecticide
	Chlordane/heptachlor	Insecticide
	Endosulfan	Insecticide
	Endrin	Insecticide
A4	Methyl bromide	Fumigant (insects, weeds, rodents, etc.)
	Lindane	Insecticide
A5	Dicamba*	Herbicide
	Amiben*	Herbicide
	Propanil	Herbicide

*Representative of the subcategory and used in the economic impact analysis of the prepared standards on this subcategory.

Organo-Phosphorus Compounds. This category contains 93 compounds used primarily as insecticides. Some widely used materials in this group are listed below:

Methyl parathion
Fenthion
Ronnel
Diazinon
Guthion
Malathion
Disulfoton

Organo-Nitrogen Compounds. Two-hundred-nine (209) compounds were identified as belonging to this group which contains some of the largest selling pesticides produced. These have been further classified into seven groups, as shown in Table W4.8.2. Most of the large selling items are herbicides, with minor production of insecticides and fungicides.

Table W4.8.2. Nitrogen-containing pesticide groupings and use

Grouping	Primary Use
C1) Aryl and alkylcarbonates	Insecticides, herbicides
C2) Thiocarbamates	Herbicides
C3) Amides and amines	Herbicides
C4) Ureas and Uracils	Herbicides
C5) s-Triazines	Herbicides
C6) Nitro compounds	Herbicides
C7) Other	Fungicides, herbicides

Metallo-organic Compounds. This is the smallest category of pesticides in both volume and value. Products are primarily fungicides and herbicides.

Formulations. In addition to the many pesticides directly manufactured, there are also many products on the market produced by formulation of combinations of pesticides or other chemicals. Good statistics are not readily available on the distribution of establishments belonging to this classification.

Pollutants and Sources

The pesticide chemical manufacturing industry is involved in the production of many complex organic materials utilizing sophisticated processes. Wastewater pollution is therefore highly variable from plant to plant.

Halogenated Organic Pesticides. The manufacture of this type of pesticide, usually results in wastewaters that contain high loadings of organic materials from operations such as decanting, distillation, and stripping. Spillage, washdowns, and runoff can also be significant if suitable operational control is not maintained. The most significant pollutants are BOD, COD, suspended solids, phenol, and the pesticide product.

Organo-Phosphorus Pesticides. There are many sources of wastewater from the manufacture of organophosphorus pesticides. These include decanter units, distillation towers, overhead collectors, solvent strippers, caustic scrubbers, contact cooling, hydrolysis units, and equipment washing.

The most significant pollutants are considered to be BOD, COD, suspended solids, ammonia, nitrogen, phosphorus, and the pesticide product.

Organo-Nitrogen Pesticides. In the manufacture of this type pesticide, the principal sources of wastewater are decanting, extractor/precipitator unit operations, scrubbing, solvent stripping, product purification, rinsing, and runoff of spillage. The significant pollutants are the same as those identified for organo-phosphorus pesticides.

Metallo-Organic Pesticides. The primary wastewater sources from the production of organo-metallic pesticides are product stripping, washing, caustic scrubbing, and cleaning operations. The significant pollutants are dissolved solids, suspended solids, BOD, COD, and the pesticide product.

Formulation and Packaging. Washing and cleaning operations are the principal sources of wastewater in the establishment.

Multicategory Producers. Previous discussions were related to plants for which the production was restricted to one category of pesticide, or to plants for which the waste from one category was identifiable. However, there are plants which produce more than one category of pesticide and, for these, the individual wastes are not readily separated.

Control Technology

The plants producing pesticides are highly variable in nature; therefore, the control technology in plants producing essentially the same product can also be highly variable. Factors such as economics, pollutant concentration, and wastewater flow have to be considered when choosing the control and treatment technology to be used.

As is the case for other industries, treatment technologies can conveniently be divided into (1) in-plant control and treatment and (2) end-of-pipe control and treatment.

In-Plant Control and Treatment. In-plant control and treatment includes steps to reduce wastewater strength and/or volume. Important in-plant techniques include proper wastewater segregation in the plant, use of dry housekeeping equipment, replacement of steam jet ejectors and barometric condensers by vacuum pumps and surface condensers, and replacement of process water by an appropriate organic solvent.

End-of-Pipe Control and Treatment. The recommended methods for end-of-pipe treatment basically involve various clean-up steps such as setting, skimming, equalization, or other treatment, followed by detoxification, usually with carbon absorption, followed by biological treatment. However, because of the highly variable nature of this industry, it is difficult to generalize about the advantages and disadvantages of the various treatments. Rather, the approach used has been to handle each on an individual basis, and to provide case histories from background information which has been obtained.

Costing Methodology

For the purpose of this report the approach used to estimate control costs was to develop model systems which would meet the wastewater guidelines and then make cost estimates for implementing those model systems in actual plants.

Model systems were planned (1) for end-of-pipe treatment to a BPT level of Subcategories A, B, and C only. Plants in Subcategories D and E should not have a wastewater discharge if properly operated. All three model plants are similar in that each waste stream contains separable organics which must be removed by an oil separator of the API type. Wastewater streams for Subcategory C also contain considerable quantities of suspended solids which can be removed in combination with the organic material. Some wastestreams contain materials from distillation tower bottoms which need to be removed and incinerated. Wastewater from Subcategory A can be detoxified by carbon absorption, while hydrolysis is the most satisfactory method for detoxification of wastes from Subcategories B and C.

The basic biological treatment consists of an activated sludge system. This should include aeration basins, flocculator-clarifiers, and sludge handling facilities.

Cost data are summarized in Table W4.8.3.

Table W4.8.3. Pesticides and Agricultural Chemicals

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	37.63	0.0	0.0	0.0
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.95	14.89	14.84	29.69	47.56
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.58	13.87	13.73	27.45	45.76
ANNUAL CAPITAL + O+M	9.52	28.76	28.57	57.14	93.31
ALL ANNUAL COSTS	9.52	28.76	28.57	57.14	93.31

Chapter W4.9 Fertilizer Manufacturing Industry

Regulations

Effluent guidelines and standards for fertilizer manufacturing were published in 1974; amendments were published in 1975 and 1976. The regulations covered BPT, BAT, NSPS and pretreatment for new sources. BCT regulations were promulgated in 1979. This report, however, does not include the effects of the amendments and regulations which were made in 1979 and 1980.

Industry Characteristics

The fertilizer industry can be divided into the production of phosphatic and nitrogenous fertilizers and the production of mixed N-P-K fertilizers. The following products are included in this sector of the chemical industry:

- Nitrogenous Fertilizers
  - Ammonia
  - Ammonium nitrate
  - Urea
  - Ammonium sulfate
- Phosphatic Fertilizers
  - Phosphoric acid
  - Ammonium phosphate
  - Triple superphosphate
- Mixed Fertilizers.

The manufacture of these fertilizers involves a variety of chemical processes. Three of the processes--phosphate rock grinding, phosphoric acid concentration, and phosphoric acid clarification--do not require process waters. The remaining processes are summarized in Table W4.9.1.

Sulfuric acid and nitric acid are intermediate products in the basic fertilizer chemicals industry. Approximately 25 percent of the plants produce these chemicals as part of the production of the final products listed earlier; they are not considered as separate plants for the purposes of this report. Plants which produce sulfuric acid or nitric acid as end products are covered under the inorganic chemicals industry.

Because fertilizers are traded in a worldwide market, and the raw materials used are also used in a wide variety of markets, the fertilizer market is subject to many outside influences. These influences include worldwide agricultural demand, the use of nitrates in explosives, and hence pressures from the international military situation, and the world market for synthetic fibers.

Table W4.9-1. Basic fertilizer chemicals manufacturing process

Product	Raw Material	Process
Wet process Phosphoric acid	Phosphate rock, sulfuric acid, water	Mixing
Normal superphosphate	Sulfuric acid, ground phosphate rock, water	mixing, curing for 3-8 weeks
Triple superphosphate	Ground phosphate rock, phosphoric acid, water	Run of pile process mixing, curing or Granular triple superphosphate process (GTSP) = mixing into a slurry, drying
Ammonium phosphates	Ammonia, wet process phosphoric acid	Similar to GTSP above
Sulfuric acid	SO_2, O_2, pelletized vanadium oxide catalyst, water	Sulfur-burning process SO_2 catalyzed to form SO_3, water added to form final product
Ammonia	Natural gas or other hydrogen source, nitrogen from air, catalysts	Hydrogen production followed by reaction with nitrogen to form ammonia
Urea	Ammonia, carbon dioxide	Ammonium carbamate formed is dehydrated to produce urea.
Ammonium nitrate	Ammonia, nitric acid	Formed by neutralization then prilled or evaporated to concentrate the product
Ammonium sulfate	Ammonia, sulfuric acid	Neutralize sulfuric acid with ammonia
Nitric acid	Ammonia, air, water, platinum-rhodium gauze catalyst	Ammonia oxidized catalytically by air, nitrogen pentoxide absorbed in water

Pollutants and Sources

The major fertilizer waste components include the following: pH, phosphorus, fluorides, total suspended solids (TSS), total dissolved solids (TDS), high temperature, cadmium, total chromium, zinc, vanadium, arsenic, uranium, radium-226, COD, oil and grease, ammonia, ammonia nitrogen, organic nitrogen, nitrate nitrogen, iron, and nickel.

The main waste sources contributing to the total waste load can be identified as coming from the following processes in each production area:

Phosphate Fertilizers

- Water treatment plant effluent including raw water filtration and clarification, water softening, and water deionization
- Closed-loop cooling tower blowdown
- Boiler blowdown
- Contaminated water (gypsum pond water)
- Spills and leaks
- Area-source discharges including surface runoff from rain or snow that becomes contaminated

Nitrogen Fertilizers

- Water treatment plant effluent including raw water filtration and clarification, water softening, and water deionization
- Closed-loop cooling tower blowdown
- Boiler blowdown
- Process condensate
- Spills and leaks that are collected in pits or trenches
- Area sources collected from rain or snow.

Mixed Fertilizers

- Wet scrubbing of drier and/or ammoniator exhaust gases
- Spills and leaks from pumps and plant wash-ups that are collected and recirculated
- Dry product from conveying equipment, when dissolved by precipitation.

In order to define waste characteristics, the following basic parameters were used to develop guidelines for meeting BPT and BAT:

Phosphate Fertilizers

- Phosphorus
- Fluorides
- Total Suspended solids and pH

Nitrogen Fertilizers

- Ammonia
- Organic Nitrogen
- Nitrate
- pH

Mixed Fertilizers

- Ammonia nitrogen
- pH
- Phosphorus
- Fluorides
- Nitrate
- Organic nitrogen.

Control Technology

Waste treatment practices in the fertilizer industry include: monitoring units, retaining areas, cutoff impoundments, reuse, recycling, atmospheric evaporative cooling, double-liming (two-state lime neutralization) surrounding dikes with seepage collection ditches, sulfuric acid dilution with pond water, evaporation, ammonia stripping (steam and air), high-pressure air/stream stripping, urea hydrolysis, nitrification and denitrification, ion exchange, cation/anion separation units, selective ion exchange for ammonia removal, oil separation, and ammonium nitrate condensate reuse.

BPT guidelines for the phosphate segment call for limitations on pH, TSS, phosphates, and fluorides by installing the following: double-lime treatment of gypsum pond water, pond design to contain a 10-year storm, monitoring system for sulfuric acid plant control, and facilities for contaminated water isolation. BPT guidelines for the nitrogen segment can be met by installing the following: ammonia steam stripping, urea hydrolysis, leak and spill control, containment and reuse, and oil separation. BPT guidelines for the mixed fertilizer segment include manufacturing process control, use of recycle water systems, recovery and reuse of wastewater, and use of dry collectors for airborne solids.

The estimates of the cost to comply with BAT are based on installation of pond water dilution of sulfuric acid for the phosphate segment and by installation of one of the following for the nitrogen segment: continuous ion exchange followed by denitrification, advanced urea hydrolysis followed by high-flow ammonia air stripping or ammonia steam stripping followed by either high flow ammonia air stripping or biological nitrification-denitrification. Because the latter two technologies were not required in the 1980 amendments to BAT limitations, costs to meet BAT guidelines may be different than those shown here. BAT and BPT guidelines are identical for the mixed fertilizer segment.

NSPS standards call for the following process improvements for the nitrogen segment (NSPS standards for the phosphate and mixed fertilizer segments are the same as the respective BAT standards):

- Integrate ammonia process condensate steam-stripping column into condensate boiler feed water systems of ammonia plant
- Use centrifugal rather than reciprocating compressors
- Segregate contaminated water collection systems so that common waste streams can be treated more efficiently and cheaply
- Locate cooling towers upwind to minimize chance of absorbing ammonia in tower water
- Design low-velocity airflow prill tower for urea and ammonium nitrate to minimize dust loss
- Design lower pressure steam levels in order to make process condensate and recovery easier and cheaper
- Install air-cooled condensers and exchangers to minimize cooling water circulation and blowdown.

Costing Methodology

Capital costs and annual operating and maintenance costs for control were estimated for model plant sizes for the various manufacturing processes on the basis of cost data presented in EPA publications. Costs for the production of ammonium sulfate and mixed fertilizers were based on cost data in 1973 dollars presented in the Economic Analysis, Phase II. Costs for all of the other products were based on cost data in 1971 dollars presented in the Development Document, Phase I. The resulting estimates of the costs of compliance are given in Table W4.9.2.

Table W4.9.2. Fertilizer manufacturing industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .824E+08

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	130.43	0.0	0.0	0.0
BAT	24.66	0.0	73.98	98.64	49.32
NEW PLANTS (NSPS)	22.20	77.30	62.27	141.66	354.79
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	46.86	207.73	136.25	240.30	404.12
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	17.15	42.01	51.45	102.89	171.48
BAT	9.73	0.0	19.45	58.36	126.44
NEW PLANTS (NSPS)	18.35	28.66	46.53	121.85	365.78
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	45.22	70.67	117.43	283.10	663.71
O + M					
EXISTING PLANTS					
BPT	42.82	104.90	128.45	256.89	427.83
BAT	18.57	0.0	37.14	111.43	240.48
NEW PLANTS (NSPS)	46.34	73.13	118.51	306.69	916.90
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	107.73	178.02	284.10	675.02	1585.21
ANNUAL CAPITAL + O+M	152.95	248.70	401.53	958.12	2248.92
ALL ANNUAL COSTS	152.95	248.70	401.53	958.12	2248.92

Chapter W4.10 Phosphorus Chemicals Industry

Regulations

Effluent limitations for the six subcategories in this industry have not changed substantially since they were originally adopted in 1974 and 1976. Control level for BPT, BAT (old), NSPS and pretreatment for new sources were specified and subsequently challenged. Portions of the regulations involving specialized definitions and new source performance standards were remanded for further study in 1976. No new guidelines for BAT or NSPS have yet been promulgated.

On October 5, 1978 the pretreatment standards for the phosphorus producing, phosphorus consuming, and phosphate subcategories were revoked. BCT and non-conventional BAT limits were proposed on August 23, 1978 for the Phase II subcategories. In 1981, the Fourth Circuit Court of Appeals remanded BCT requirements because it found that the basis for setting them was unsound. This chapter does not reflect this change, and this includes costs for both BPT and BCT.

Phosphorus Chemicals (Phase I)

Industry Characteristics. Establishments included in the phosphorus chemicals manufacturing industry as defined by the Phase I effluent limitations guidelines are manufacturers of the following chemicals:

- Phosphorus
- Ferrophosphorus
- Phosphoric acid (dry process)
- Phosphorus pentoxide
- Phosphorus pentasulfide
- Phosphorus trichloride
- Phosphorus oxychloride
- Sodium tripolyphosphate
- Calcium phosphates (food grade)
- Calcium phosphates (animal feed grade).

This industry is almost entirely based on the production of elemental phosphorus from mined phosphate rock. Elemental phosphorus and ferrophosphorus (a by-product) are manufactured by the reduction of phosphate rock by coke in very large electric furnaces, using silica as a flux. Because elemental phosphorus is relatively low in weight compared to phosphate rock and phosphoric acid, the elemental phosphorus is produced near the mining site and shipped to locations near the final markets for further processing.

Over 87 percent of the elemental phosphorus is used to manufacture high-grade phosphoric acid by burning liquid phosphorus in air, the subsequent quenching and hydrolysis of the phosphorus pentoxide vapor, and the collection of the phosphoric acid mist.

The manufacture of the anhydrous phosphorus chemicals--phosphorus pentoxide (P_2O_5), phosphorus pentasulfide (P_2S_5), and phosphorus trichloride (PCl_3)--is essentially the direct union of phosphorus with the corresponding element. Phosphorus oxychloride ($POCl_3$) is manufactured from PCl_3 and air or from PCl_3, P_2O_5, and chlorine.

Sodium tripolyphosphate is manufactured by the neutralization of phosphoric acid with caustic soda and soda ash in mix tanks. The resulting mixture of mono- and disodium phosphates is dried and the crystals calcined to produce the tripolyphosphate.

The calcium phosphates are similarly made by the neutralization of phosphoric acid with lime. The amount and type of lime used and the amount of water used in the process determine the final product-- anhydrous monocalcium phosphate, monocalcium phosphate monohydrate, dicalcium phosphate dihydrate, or tricalcium phosphate. Animal feed grade dicalcium phosphate is produced by almost the same process as the other calcium phosphates. Because of the lower purity needed in the final product, defluorinated, wet process phosphoric acid is normally used and the reaction may be conducted without excess water.

For the most part, the products included in the phosphorus chemical industry are produced by divisions of large chemical or petroleum companies. The derivatives of phosphorus are generally manufactured by the same companies that produce elemental phosphorus, but in different locations. Furthermore, a large proportion of the products are used internally by the producing company for the production of other products and, hence are not sold on the open market.

The biggest factors determining the future of the industry are government regulations and technological innovations. The declining production of phosphorus, for example, is the result of government bans on phosphate detergents. In addition, the TVA plant was shut down in 1976, as a shift to production of wet phosphoric acid was accomplished.

Pollutants and Sources. Water is primarily used in the phosphorus chemical industry for eight principal purposes: non-contact cooling water, process and product water, transport water, contact cooling or heating water, atmospheric seal water, scrubber water, auxiliary process water, and water used for miscellaneous purposes. Very large quantities of non-contact cooling water are used for cooling the electric furnaces used in phosphorus production. Contact cooling water is used to quench the slag from the phosphorus furnaces. Process or product water contacts and generally becomes part of the product, such as the hydrolysis and dilution water used in phosphoric acid manufacture and the water used as a reaction medium in food-grade dicalcium phosphate manufacture. Because yellow phosphorus spontaneously ignites on contact with air, air is kept out of reaction vessels with a water seal. Liquid phosphorus is protected by storage under a water blanket; these seal waters are considered process waters. Auxiliary process waters include those used in such auxiliary operations as ion exchange regeneration, equipment washing, and spill and leak washdown.

The following pollutant parameters have been designated for the industry's process wastewaters: total suspended solids, phosphate and elemental phosphorus, sulfates and sulfites, fluoride, chloride, dissolved solids, arsenic, cadmium, vanadium, radioactivity, temperature (heat), and pH. The primary parameters, i.e., those which need to be used to set effluent standards, are total suspended nonfilterable solids, total phosphorus, fluoride, arsenic, and pH. The remaining pollutants are either adequately treated when the primary parameters are treated, or are present only in waste streams for which a no-discharge standard has been set.

The effluent limitations guideline for most of the phosphorus chemical industry is no discharge of process wastewater pollutants to navigable waters. Process water is defined as any water that comes into direct contact with any raw material, intermediate product, by-product, or gas or liquid that has accumulated such constituents.

The only exceptions to these standards are the BPT guidelines for phosphorus and ferrophosphorus, phosphorus trichloride, phosphorus oxychloride, and food-grade calcium phosphates.

Control Technology. Control and treatment of wastes are of the chemical variety. These include neutralization, precipitation, ionic reactions, filtration, centrifugation, ion exchange, demineralization, evaporation and drying. In-process abatement measures include segregation of waste streams, recycling of scrubber water, dry dust collection, containment of leaks and spills, and minimization of the quantity of wash water. Many of the manufacturing establishments currently have no treatment installed, while others have already achieved a no-discharge status.

The technology recommended to achieve zero discharge of wastewaters in the phosphorus chemical industry consists of:

- Recycling atmospheric seal ("phossy") waters, scrubber liquors, and other process waters following lime treatment and sedimentation (or alternative methods of reducing water flow, such as the use of dilute caustic or lime slurry instead of pure water in the process)
- Use of dry dust collectors
- The return of process waste streams and blowdown streams to the process.

Zero discharge of arsenic-rich still residues from the manufacture of phosphorus trichloride can be achieved through treatment with trichloroethylene.

For those industry subcategories where some discharge is allowed, the recommended treatment consists of waste-reducing steps such as those above, but with some discharge following lime treatment and sedimentation, sometimes with flocculation. Additional treatment to achieve no-discharge for these subcategories consists of:

- Total recycling of all process waters by the phosphorus producer
- Control of PCl_3 vapors by installation of refrigerated condensers, minimization of wastewaters with treatment by lime neutralization followed by evaporation to dryness (for manufacturers of phosphorus trichloride and phosphorus oxychloride)
- The addition of vacuum filtration of treated wastewaters followed by total recycling (for producers of food-grade calcium phosphates).

Phosphorus Chemicals (Phase II)

Industry Characteristics. Establishments included in this industry sector manufacture phosphate products by processes that include a defluorination step. The specific products included are defluorinated phosphate rock, defluorinated phosphoric acid (both in SIC 2874, Phosphate Fertilizers), and sodium tripolyphosphate (STPP, in SIC 2819, Industrial Inorganic Chemicals, n.e.c.) produced from wet-process phosphoric acid. The one plant that produces STPP by this process was included in the Phase I report with the 17 plants that use furnace process phosphoric acid, so STPP will not be considered here.

The defluorination of phosphate rock is accomplished in a rotary kiln or fluid-bed reactor. The rock is blended with sodium-containing chemicals, wet-process phosphoric acid, and silica then defluorinated in the reactor at 1200-1400C (2200-2600F).

Wet-process phosphoric acid is defluorinated by either of three processes. In two of the processes, wet process phosphoric acid is dehydrated by evaporation to produce superphosphoric acid, and defluorination is accomplished adventitiously. The evaporation may be accomplished by either vacuum or submerged combustion processes. Defluorinated phosphoric acid can be produced by an aeration process in which fine silica is added to wet-process phosphoric acid and is removed ultimately, along with fluoride, as volatile silicon tetrafluoride under conditions that do not remove water.

The major use for defluorinated phosphate rock is as an ingredient of animal feeds. Production of this product has been increasing at a rate of nearly 4.5 percent per year since 1968, and is expected to show a similar growth rate through 1986. A large fraction of defluorinated phosphoric acid is used to produce dicalcium phosphate for animal feeds. Increasingly large quantities are being used in liquid fertilizers and as an intermediate in the production of dry mixed fertilizers. The production of superphosphoric acid from wet-process phosphoric acid is expected to increase at about 9.5 percent per year. Defluorinated phosphoric acid other than the super acid is expected to increase at about 4 percent per year.

Pollutants and Sources. The major source of water pollution in these processes is the water used to scrub contaminants from gaseous effluent streams. Process conditions are such that recirculated contaminated water can be used for this purpose. Spills and leaks are collected and added to the contaminated water pond.

The proposed effluent limitations guidelines specify no discharge of process wastewaters except under certain chronic or catastrophic precipitation events. If wastewaters must be discharged under such events, they must be treated so they do not exceed the following limitations:

	Daily Maximum, mg/l	30-Day Average, mg/l
Suspended solids	150	50
Phosphorus	105	35
Fluoride	75	25
pH	Within the range 6.0 to 9.0	

Control Technology. The major control technology is the use of ponds of adequate size. To accommodate rainfall incidents for BPT, at least 60 cm (24 inches) freeboard is required (150 cm or 60 inches in Florida). For BAT, additional dike height is required (assumed for cost purposes to be 15 cm or 6 inches).

To achieve the necessary reduction of contaminants for discharge of waters, pond water can be treated with lime to neutralize the phosphorus and fluorides. Solids are then settled prior to discharge. Two separate settling ponds are needed for contaminated water treatment -- one each for calcium fluorides and calcium phosphates. Most of the existing plants already meet BAT guidelines.

Industry Cost Model

The approach to estimating the costs of compliance for the above categories of operations consisted of developing model plant populations and cost functions for each of the subcategories defined by the regulations. Data were obtained from the EPA Development and Economic Analysis Documents, and modified or updated with information from the NCWQ study of 1975, the 1976 NBER study for EPA, and data from the 1979 Directory of Chemical Producers. Although BAT guidelines have been remanded, permit writers may still impose BAT level discharge limitations.

The costs indicated under the BAT category refer to the costs incurred beyond BPT which are imposed by individual permit conditions. The estimated costs developed on the above basis are given in Table W4.10.1.

Table W4.10.1. Phosphorus chemicals industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .180E+09

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	71.94	0.0	0.0	24.52
BAT	10.43	0.0	22.76	42.37	30.05
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10.43	71.94	22.76	42.37	54.57
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	9.46	22.85	28.38	56.75	96.53
BAT	2.99	0.0	4.89	20.48	52.01
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	12.45	22.85	33.27	77.23	148.54
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	10.22	21.64	29.63	64.17	147.02
BAT	4.34	0.0	8.09	29.90	88.06
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	14.57	21.64	37.72	94.06	235.08
ANNUAL CAPITAL + O+M	27.02	44.50	70.98	171.29	383.62
ALL ANNUAL COSTS	27.02	44.50	70.98	171.29	383.62

Chapter W4.11 Paint Formulating

Regulations

New regulations were proposed in January of 1980 (45CFR912) for BPT, BAT, NSPS, PSES and PSNS for this industry. Subsequently, this industry was excluded from Paragraph 8 under a settlement agreement. These proposed regulations and their impacts are not reflected in the text of this chapter nor costed along with other regulations. Regulations established through 1975 are costed and discussed in the text of this chapter.

The original regulations published in 1975 cover only solvent-based production operations. The regulations established in 1980 are based on the premise that water-based production operations would also be required to achieve no discharge of process wastewater pollutants. Pretreatment is required in cases where the discharge of water-based paint wastes could cause sewer maintenance problems because of solids settling in low spots or adhering to sewer walls.

Industry Characteristics

The manufacturing of paint involves the mixing or dispersion of pigments in oil, resin, resin solution, or latex. Mixing is then followed by the addition of specified portions of organic solvents or water to obtain the desired viscosity.

In 1972 there were 1,599 plants manufacturing paint and allied products in the United States. Production is not divided evenly among these plants. Roughly 40 percent of the plants, each employing fewer than 10 persons, shipped only 3 percent of the total value of shipments for the industry. Plants employing 250 or more workers accounted for less than 10 percent of the number of plants, and 33 percent of the industry's total value of shipments.

A historic trend in the industry toward fewer and larger plants is expected to continue.

In 1976, total production is estimated at 4,644 million liters (1,227 million gallons), with about 22 percent water-based. It is estimated that total production will be about 7,525 million liters (1,988 million gallons) in 1986, 29 percent of which is expected to be water-based. Production of water-based paints was 754.4 million liters (199.3 million gallons) in 1972, about 1,022 million liters (270 million gallons) in 1976, and should be about 2,184 million liters (577 million gallons) in 1986.

Pollutants and Sources

The products of the paint industry are either solvent-based or water-based. The production of solvent-based paints produces little wastewater effluent. The bulk of the wastewater from the industry is the result of clean-up operations in the manufacture of water-based paints. Most paint plants are located in highly industrialized urban areas near the markets, and most of the wastewater is discharged to municipally operated sewer systems, with or without pretreatment.

The major wastewater contaminants in paint plants are pigments and latex. Other significant water pollutants are driers and wetting agents, oils, resins, and caustics (used in cleaning). There may also be some contamination by fungicides (including mercurials), heavy metals, and solvents. Recent State and Federal regulations are forcing the paint industry to find substitutes for mercurial biocides. Cadmuim, lead, and other heavy metals should appear mainly as insoluble pigments and should be readily controllable as suspended solids. Furthermore, the Lead-Based Paint Poisoning Prevention Act of 1973 has forced the search for suitable replacements for lead pigments and drying agents. The quantities of organic solvents that reach wastewater streams are very small.

Control Technology and Costs

For solvent-based paint production, good housekeeping, with control of spills and leaks, will allow all wastewater pollutants to be collected in sumps, placed in drums, and periodically disposed of in a landfill. The base level of practice is already no discharge of process waste liquids, so BPT, BAT, and NSPS can be achieved at no cost. Negligible cost would be required to insure good housekeeping and prevent leaks and spills from being discharged to surface waters.

The added cost of achieving no discharge of water pollutants in manufacturing oil-based paints is zero. Most oil-based paints are produced for trade sales, not industrial finishes. Data extrapolated from a survey conducted by the National Paint and Coatings Association (NPCA) shows that only 44 plants producing trade sales paints were discharging water pollutants to surface water. All other plants producing trade sales paints were discharging wastewaters in some apparently approved manner and should have no compliance costs for meeting EPA standards. Of these 44 nonconforming plants, 22 were large, 10 medium, 6 small, and 6 very small.

For water-based paints, the control technology selected to minimize costs is greatly affected by plant size. Small plants, averaging about 7,600 liters per day (2,000 gallons per day) of paint production, can best achieve zero discharge by minimizing water use and recycling wash waters through a packaged system for settling and sludge collection. Larger plants, averaging about 19,000 liters per day (5,000 gallons per day) production, would be better off installing a mechanical automatic high-pressure spray-cleaning system with recycle.

Based on the anticipated production of approximately 2,200 million liters (575 million gallons) of water-based paints in 1986, new capacity above the 1972 level will be required to produce about 1,400 million liters (f370 million gallons) per year, or about 5.5 million liters (1.1 million gallons per day). This new production can be achieved with 240 new large plants, producing an average of 23,000 liters (6,000 gallons) of paint per day. These new plants will be required to meet New Source Performance Standards.

Control costs based on the above condition are summarized in Table W4.11.1.

Table W4.11.1. Paint formulating

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.129E+07 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	8.52	0.0	0.0	3.84
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	1.36	4.69	3.80	8.58	20.65
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.36	13.21	3.80	8.58	24.49
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	1.12	3.92	3.36	6.72	11.12
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	1.12	1.76	2.82	7.40	21.86
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.24	5.68	6.19	14.12	32.98
O + M					
EXISTING PLANTS					
BPT	0.95	3.32	2.84	5.68	9.47
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.94	1.49	2.39	6.26	18.60
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.89	4.80	5.23	11.94	28.07
ANNUAL CAPITAL + O+M	4.13	10.48	11.42	26.06	61.05
ALL ANNUAL COSTS	4.13	10.48	11.42	26.06	61.05

Chapter W4.12 Printing Ink Formulating

Regulations

New regulations were proposed in January of 1980 (45FR928) for BPT, BAT, NSPS, PSES, and PSNS for this industry. Subsequently, this industry was excluded from Paragraph 8 under a settlement agreement. These proposed regulations and their impacts are not reflected in the text of this chapter. The costs shown here are based on documentation associated with the regulations originally promulgated.

Industry Characteristics

The ink manufacturing industry resembles the paint manufacturing industry, although it is considerably smaller in size. The industrial sector described here is contained in SIC 2893 with captive shops appearing in SIC 27.

Printing ink production in the United States exceeds 450 thousand metric tons (one billion pounds) per year. The major components include drying oils, resins, varnish, shellac, pigments, and many specialty additives.

The profile of the paint industry is applicable to inks also. Many of the raw materials are the same and the methods of producing ink and the equipment used are nearly identical to those for producing paint. Milling is used more extensively in the ink industry as a method of dispersing pigments.

Printing inks can be either water- or oil-base. Many of the raw materials are the same regardless of the vehicle. The waste characteristics are similar to the paint counterpart.

A check of the Refuse Act Permit Program applications and consultation with industrial representatives led to the conclusion that there are no ink manufacturing plants in the country discharging process wastes to surface streams.

Many of the plants that are on municipal systems practice no discharge of wastewater pollutants. Ink process wastewaters are either sent to sanitary landfills for disposal or the wastewaters are recycled and reused with the plant. A limitation of "no discharge of process wastewater pollutants" would have little, if any, effect on the industry.

Pollutants and Sources

Oil-base ink discharges contain substances whose entry into most municipal sewer systems or surface waters is prohibited. Most cities have waste ordinances which have attempted to deal with the release of these substances. Due to the highly volatile nature and the odor of these materials, the source of any substances that do find their way into the sewer system through accidental spills could quickly be located.

Water-base ink discharges would generally be classified as acceptable to municipal treatment systems. The possibility of solids causing sewer maintenance problems depends on the pipe size and hydraulic load in the sewer. Some of the organic pigments have colors that are highly persistent, and therefore they are not removed by existing treatment methods.

The general practice of the ink formulating industry is to discharge only to municipal sewers. There are no known discharges of process wastes directly to waterways.

Control Technology and Costs

As ink formulators do not discharge wastes to water courses and their wastes are generally considered to be compatible with municipal treatment except for problems of brilliant colors and solids, few data are available on the waste characteristics. The practices of recycling wastewater and water conservation can reduce the quantity of ink waste discharged to the sewers.

The significant parameters for measuring the pollution potential of ink wastes are BOD_5, COD, pH, total suspended solids (TSS), heavy metals, and color.

As the ink manufacturing plants discharge only to municipal systems, there is little sophistication in the treatment methods. The complexity of the treatment process is a function of the restrictions applied by the municipality. In areas where high surcharges are placed on BOD and TSS, there is a trend toward strict water conservation, reuse, and disposal of ink solids to landfills.

Sedimentation is the most common treatment method employed due to the high level of suspended solids in the wastewater. Flocculation is also used to increase the effectiveness of removing suspended solids. Neutralization, principally of caustic cleaning solutions, is employed to some degree. The only wastewaters requiring control in the ink industry are the wash and rinse solutions resulting from cleanup.

A summary of the costs for the printing ink industry is shown in Table W4.12.1.

Table W4.12.1. Printing ink formulating

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.129E+07 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	2.88	0.0	0.0	0.0
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.38	1.77	1.14	2.27	3.11
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.13	0.45	0.39	0.77	1.28
ANNUAL CAPITAL + O+M	0.51	2.22	1.52	3.04	4.39
ALL ANNUAL COSTS	0.51	2.22	1.52	3.04	4.39

Chapter W4.13 Photograph Processing

Regulations

The Photographic Processing industry comprises a single subcategory for which only BPT level controls have been promulgated (41 CFR 29078, July 14, 1976).

Industry Characteristics

The photographic processing subcategory of the photographic point source category is defined to include all film processing activities listed under SIC 7221 (Photographic Studios, Portrait), SIC 7395 (Photofinishing Laboratories), and SIC 7819 (Developing and Printing of Commercial Motion Picture Film).

Of the estimated 12,500 processing plants in the United States approximately 3,000 are amateur operations, 3,000 are "captive" laboratories in business and industrial firms, 650 are major laboratories specializing in work for professional and industrial photographers, and the remaining plants are portrait and commercial studios.

The photographic processing subcategory serves the photographic trade, the military establishment, the scientific community, the medical profession, the dental profession, and the general public in the developing of films and in photoprinting and enlarging. Only 650 major laboratories have significant wastewater discharges. Approximately 5 percent of all major photoprocessing plants are classified as existing point sources and, therefore, are subject to the effluent limitations discussed here. The remaining 95 percent of the plants discharge their wastewater to municipal treatment systems.

Plant sizes range from small amateur operations to the major laboratories which may process as much as 9,000 square meters (100,000 square feet) of film and paper daily. Many plants process between 2,000 and 5,000 square meters (between 25,000 and 50,000 square feet) per day. These plants are located in urban areas throughout the country.

The products produced by the industry are primarily finished color and black and white films and prints, produced in a wide variety of photoprocessing machines used to finish a specific film or paper. The nature, basic principles and waste characteristics of the photographic processing are the same in all facilities regardless of size and age. The quantity of waste per unit of production shows a consistent relationship.

Pollutants

Parameters of major concern are BOD_5, COD, silver and cyanides in various forms including complexes (ferrocyanide and ferricyanide).

Control Technology

After varying degrees of in-plant pollution abatement measures which serve as a pretreatment step most photographic processing plants discharge their effluents to municipal sewer systems. Certain constituents (i.e., silver and cyanide) which could exert toxic effect on a biological system and various non-biodegradable material may also be present. Therefore, in-plant measures or pretreatment to reduce the concentrations of such contaminants to levels acceptable to local authorities must be utilized.

To avoid substantial economic injury to small business concerns, a size exemption for photographic processing plants handling less than 150 square meters (1,600 square feet) per day of film was established. Implicit in the recommended guidelines for the photographic processing subcategory of the photographic point source category is the use of in-plant control measures to reduce silver and cyanide. In-plant modifications will lead to reductions in wastewater flow, increasing the quantity of water used for recycle, and improving the raw wastewater quality. In-plant treatment technologies should be utilized by the photographic processing subcategory to achieve BPT effluent limitations and guidelines.

The selection of technology options depends on the economics of that technology and the magnitude of the final effluent concentration. Control and treatment technology may be divided into two major groupings: in-plant pollution abatement and end-of-pipe treatment. Applicable technologies are outlined as follows:

In-plant Pollution Abatement--Regeneration and Reuse

- Silver Recovery
  - Metallic Replacement
  - Electrolytic Recovery
  - Ion Exchange
  - Sulfide Precipitation

- Regeneration of Ferricyanide Bleach
  - Persulfate Regeneration
  - Ozone Regeneration

- Developer Recovery
  - Ion Exchange
  - Precipitation and Extraction

- Use of squeegees (to inhibit carry-over from one tank to the next)

- Use of Holding Tanks (for slow release rather than dumping)

End-of-Pipe Treatment

- Biological Treatment
  -Activated Sludge
  -Lagoons

- Physical/Chemical Treatment
  -Ozonation
  -Activated Carbon Adsorption
  -Chemical Precipitation
  -Reverse Osmosis

Costing Methodology

Capital investment and Operating and Maintenance cost functions were taken from the Development Document, which gave estimated costs for two plant sizes: 128.3 and 1283 thousand square meters per year production. Only 650 plants have significant wastewater flows, and 95 percent of these are on sewers. Capital and O&M costs for BPT standards for a 128.3 thousand square meters per year plant (5,000 square feet per day) are $112,370 and $12,540 respectively (in 1979 dollars). These BPT costs represent the minimum-cost technology: in-plant changes to achieve control of silver and cyanide.

Since BPT regulations were effective upon promulgation in July 1976, and called for BPT compliance for July 1, 1977, 100 percent compliance was achieved in twelve months. The Development Document points out, however, that in reality, a great degree of treatment has been practiced by industry for some time for economic reasons.

This report assumes an industry growth corresponding to the growth of GNP--approximately 4 percent. This is a departure from previous estimates, which assumed an 8.5 percent growth.

A summary of costs for the treatment of photographic wastes appears in Table W4.13.1.

Table W6.13.1. Photograph processing

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS (CAPITAL IN PLACE 1972) [illegible]	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	3.72	0.0	0.27	4.95
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PUBL/PRETREAT	0.0	0.0	0.0	0.0	0.0
OTHER	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	3.72	0.0	0.27	4.95
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.61	1.80	1.82	3.65	7.05
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PUBL/PRETREAT	0.0	0.0	0.0	0.0	0.0
OTHER	0.0	0.0	0.0	0.0	0.0
TOTAL	0.61	1.80	1.82	3.65	7.05
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	1.21	3.10	3.50	7.43	14.17
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PUBL/PRETREAT	0.0	0.0	0.0	0.0	0.0
OTHER	0.0	0.0	0.0	0.0	0.0
TOTAL	1.21	3.10	3.50	7.43	14.17
ANNUAL CAPITAL + O&M	1.82	4.90	5.31	11.08	21.22
ALL ANNUAL COSTS	1.82	4.90	5.31	11.08	21.22

Chapter W4.14 Textile Mills

Regulations

Regulations for the Textile Mills Point Source Category were promulgated in July 1974 and covered BPT, BAT, NSPS, and pretreatment standards for new sources (PSNS)(Ref. 1). In January 1975, the BAT regulations were challenged in the courts with the result that EPA was required to reconsider BAT in light of technological and economic data developed by the textile industry. In May 1977, regulations were promulgated for PSES and, two years later, proposed for BCT and revised BAT. These latter regulations were also proposed to supercede prior NSPS, PSNS, and PSES. In September 1982, regulations were promulgated to supercede all existing regulations, except BPT. These regulations, which establish nine subcategories, set BAT limitations equal to the previously promulgated BPT and based NSPS on the median performances of the best biological treatment systems currently used to treat textile mill wastewaters; the regulations do not establish categorical pretreatment standards for existing or new source indirect dischargers.

Industry Characteristics

The textile industry, which is classified in SIC Major Group 22, Textile Mill Products, comprises establishments primarily engaged in receiving and preparing fibers; transforming these materials into yarn and web into fabric or related products; and finishing these materials at various stages of the processing. The entire industry includes approximately 7000 mills and plants. However, of this total less than 1500 are engaged in finishing (or scouring) which involves the generation of process-related wastewater discharge. These establishments are the point sources to which the proposed regulations apply. The subcategories of the Textile Mills Point Source Category are listed below along with the numbers of direct and indirect dischargers for each of the subcategories.

Subcategory	Number of Direct Dischargers	Number of Indirect Dischargers	Total
Wool scouring	6	10	16
Wool finishing	8	26	34
Low water use processing 1/	69	227	296
Woven fabric finishing 2/	85	243	328
Knit fabric finishing 3/	46	385	431
Carpeted finishing	11	45	56
Stock and yarn finishing	36	178	214
Nonwoven manufacturing	5	26	31
Felted fabric processing	1	15	16
Total	267	1155	1422

1/ Includes water jet weaving subdivision.

2/ Includes 3 subdivisions: Simple processing, complex processing, and desizing.

3/ Includes 3 subdivisions: Simple processing, complex processing, and hosiery products.

Most of the facilities in the nine subcategories are concentrated along the Eastern Seaboard--80 percent are located in the Mid-Atlantic and Southern regions while the remaining are distributed about equally between New England and the North Central and Western regions. The mills and plants in New England are generally the older facilities in the industry while those in the Southern states are, in most cases, its newer ones.

The value of shipments for the textile industry have increased from $31 billion in 1975 to over $56 billion in 1981 for an average annual increase of over 10 percent. The largest increases occurred in the mid-1970s. Since 1977 the annual increases have been less than 10 percent with a 9.2 percent change occurring between 1979-1980 and 3.7 between 1980 through 1981.

Pollutants and Sources

Many textile plants are integrated and perform dry, low water use, and major wet-processing operations. Principal dry operations include spinning, tufting, knitting, and weaving. Principal low water use operations include slashing, web formation (nonwoven manufacturing only), bonding, adhesive processing, coating, and functional finishing. Major wet operations include scouring, carbonizing, fulling, desizing, mercerizing, bleaching, dyeing, and printing. It is in these major wet operations that the major waste effluents are produced. Table WQ.14.1 lists those pollutants generated by the major wet operations in the textile industry.

The most significant pollutants and pollutant parameters in terms of occurrence and concentration include:

Table W4.14.1. Wastewater pollutants and their sources for the textile industry 1/.

Process	Wastewater Pollutants
1. Raw Wool Scouring	1. Significant quantities of natural oils, fats, suint, and adventitious dirt. Also includes sulfur, phenolies, and other organic compounds brought in with wool.
2. Carbonizing	2. Residual sulfuric acid and neutralizing agents (generally sodium carbonate). Acid bath must be dumped when it becomes too contaminated for efficient carbonization. Wastewater is high in total solids.
3. Fulling	3. The two common methods of fulling are acid and alkali. The wastewater from acid fulling will contain sulfuric acid, hydrogen peroxide, and small amounts of metallic catalysts (chromium, copper, or cobalt). The wastewater from alkali fulling will contain soap or detergent, sodium carbonate, and sequestering agents (phosphate compounds).
4. Desizing	4. Desizing contributes a significant amount of organic load, some oil and grease, and most of the suspended material found in woven fabric finishing wastewater. Enzymatic removal generates starch solids, fat, wax, enzymes, sodium chloride and wetting agents. Sulfuric acid removal generates starch solids, fat, wax, and sulfuric acid.
5. Scouring	5. The nature of the scouring operation is highly dependent on the fiber type thus, the hydraulic and organic load of the wastewater will contain detergents, wetting agents, emulsifiers, alkali, and ammonia. Cotton and cotton-synthetic fiber blend wastewaters will contain significant quantities of oil and grease, some suspended solids, sodium hydroxide, phosphate, chelating agents, and wetting agents. Synthetic fibers wastewaters will contain weak alkalis, anti-static agents, lubricants, and soap or detergents.

Continued...

Table W4.14.1 (Continued)

Process	Wastewater Pollutants
6. Mercerizing	6. Wastewater contains high levels of dissolved solids and may have a pH of 12 to 13. Also may include small amounts of foreign material and wax.
7. Bleaching	7. Primarily accomplished with hydrogen peroxide. Hydrogen peroxide bleaching contributes very small waste loads, most of which are inorganic (sodium silicate, sodium hydroxide, and sodium phosphate) and organic (surfactants and chelating agents) dissolved solids. Also includes a low level of suspended solids when goods containing cotton are bleached.
8. Dyeing	8. Wastewater contains dyestuff and other auxiliary chemical such as acids, bases, salts, wetting agents, retardants, accelerators, detergents, oxidizing agents, reducing agents, developers, and stripping agents. Color is an obvious adverse pollutant and high levels of dissolved solids are present.
9. Printing	9. Waste water constituents are similar to dyeing although the volumes are much lower and the concentrations greater. The thickeners contribute to the BOD, and solvents used to prepare pigments and clean pigment equipment are often present.

1/ Source: Reference (6)

Toxic pollutants

- acrylonitrile
- benzene
- 1, 2, 4-trichlorobenzene
- 2, 4, 6-trichlorophenol
- parachlorometacresol
- chloroform
- 1, 2-dichlorobenzene
- ethylbenzene
- trichlorofluoromethane
- naphthalene
- N-nitrosodi-n-propylamine
- pentachlorophenol
- phenol
  - (a) 4--AAP
  - (b) GC/MS
- bis(2-ethylhexyl) phthalate
- tetrachloroethylene
- toluene
- trichloroethylene
- antimony
- arsenic
- cadmium
- chromium
- copper
- cyanide
- lead
- mercury
- nickel
- selenium
- silver
- zinc

Conventional pollutants

- BOD
- TSS
- oil and grease
- pH

Nonconventional pollutants

- COD
- color

Control Technologies

The technology for control and treatment of waterborne pollutants in the textile industry can be divided into two broad categories: (1) in-plant controls and process changes and (2) end-of-pipe treatment. In-plant controls and process changes are measures taken to reduce hydraulic and pollutant loadings originating from mill operations.

In-plant control measures may be divided into the following five types: (1) water reuse; (2) water reduction; (3) chemical substitution; (4) material reclamation; and (5) process changes and new process technology. EPA has evaluated all of the in-plant control technologies and process changes in developing the regulations promulgated in the Federal Register of September 16, 1982. However, EPA did not consider any specific one in establishing the effluent limitations for existing or new source dischargers. Basically, there are no specific control measures that are necessary in the industry as a whole or in one or more particular subcategories.

End-of-pipe treatment of combined waste streams is currently the principal approach being taken by the textile industry to remove or reduce the pollutants present in the waste from the various wet-processing operations. This has been, and seems to remain, the approach because of the difficulty of segregating waste streams at existing facilities. However, new facilities will no doubt be designed so that the more concentrated and more troublesome wastes can be segregated and treated independently. The recommended technologies for achieving BPT and NSPS for each subcategory of the manufacturing processes are listed in Table W4.14.2 (BAT equals BPT). No PSES or PSNS has been established for the textile industry.

Costing Methodology

Water pollution control costs to the textiles industry for compliance with effluent limitations, pretreatment standards, and new source performance standards were developed for each of the various industry subcategories. Costs were estimated by developing cost equaions for each of the industry subcategories for both direct and indirect dischargers for all pertinent control technologies. Cost equations were developed in the form of $y = Ax^b$, where:

y = Capital investment cost or O&M cost;
x = Daily plant production or capacity.

The cost equations were developed from data obtained in the Development Document for BPT and from the Economic Analysis for NSPS.

Table W4.14.3 summarizes the compliance costs for the textile industry.

Table W4.14.2. Control technologies by subcategory for direct dischargers

Subcategory	BPT	NSPS
1. Wool scouring	1. Screening 2. Primary sedimentation 3. Extended aeration activated sludge with solids recycle 4. Secondary sedimentation	No new source plants expected
2. Wool finishing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
3. Low water use processing water jet weaving	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
4a. Woven fabric finishing - simple processing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
4b. Woven fabric finishing - complex processing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
4c. Woven fabric finishing - desizing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
5a. Knit fabric finishing - simple processing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
5b. Knit fabric finishing - complex processing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
5c. Knit fabric finishing - hosiery products	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
6. Carpet finishing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
7. Stock and yarn finishing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
8. Nonwoven manufacturing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	Same as BPT
9. Felted fabric processing	1. Screening 2. Extended aeration activated sludge with solids recycle 3. Sedimentation	No new source plants expected

Table W4.14.3. Textile mills

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE [illegible]: .628E+00

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	23.45	0.0	2.54	21.16
BAT	0.0	0.0	0.0	2.47	3.32
NEW PLANTS(NSPS)	5.11	36.40	19.55	40.96	97.64
[illegible]	0.0	0.0	0.0	0.0	0.0
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	5.11	59.85	19.55	45.97	122.12
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	3.82	12.14	11.45	22.86	36.23
BAT	0.0	0.0	0.0	0.80	4.04
NEW PLANTS(NSPS)	9.11	17.27	24.65	56.92	125.45
[illegible]	0.0	0.0	0.0	0.0	0.0
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	12.92	29.41	36.10	80.58	165.73
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	3.57	11.35	10.71	21.42	35.70
BAT	0.0	0.0	0.0	1.17	6.01
NEW PLANTS(NSPS)	10.23	19.40	27.69	64.19	147.66
[illegible]	0.0	0.0	0.0	0.0	0.0
[illegible]	0.0	0.0	0.0	0.0	0.0
TOTAL	13.80	30.75	38.40	86.78	189.37
ANNUAL CAPITAL + O&M	26.72	60.17	74.49	167.36	355.10
ALL ANNUAL COSTS	26.72	60.17	74.49	167.36	355.10

Chapter W5. Metals Industries

For the purpose of this report, the Metals Industries are defined as those establishments which are primarily engaged in the mining, refining, extracting, processing, fabricating or recovering of ferrous and nonferrous metals, and processes performed by establishments in direct support of these operations. The industries included are:

- Ore Mining and Dressing Industries
- Iron and Steel
- Ferroalloys Industry
- Bauxite Refining Industry
- Primary Aluminum Smelting Industry
- Secondary Aluminum Smelting Industry
- Electroplating and Metal Finishing Industry
- Coil Coating
- Porcelain Enameling

Costs are associated with the implementation of the FWPCA for the metals industries are summarized in Table W5.

TABLE W 5. METALS
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

				INVESTMENT		
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 5. 1	ORE MINING & DRESSING	0.0	455.30	212.61	212.61	0.0
W 5. 2	IRON & STEEL	138.28	1537.91	461.33	937.30	896.48
		[illegible]	28.69	1.83	5.13	6.14
W 5. 4	BAUXITE REF.	0.0	98.14	0.0	0.0	0.0
W 5. 5	PRIMARY ALUM.	0.57	49.97	26.20	34.77	28.94
W 5. 6	SECONDARY ALUMINUM	1.59	9.56	4.66	9.51	26.10
W 5. 7	ELECTROPLATING	0.0	0.0	0.0	662.33	785.27
W 5. 8	COIL COATING	4.30	0.0	11.11	25.33	32.70
W 5. 9	PORCELAIN ENAMELING	0.69	0.0	6.77	23.75	17.07
	TOTAL INVESTMENT	150.20	2179.57	724.32	1910.73	1792.71

				ANNUAL COSTS		
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 5. 1	ORE MINING & DRESSING	165.60	221.95	486.76	983.80	1656.81
W 5. 2	IRON & STEEL	383.51	947.67	1025.06	2404.08	4891.98
W 5. 3	FERROALLOYS	12.42	34.67	36.88	78.16	140.40
W 5. 4	BAUXITE REF.	23.51	82.28	70.52	141.04	225.40
W 5. 5	PRIMARY ALUM.	29.31	53.91	77.74	175.64	376.70
W 5. 6	SECONDARY ALUMINUM	7.31	12.07	19.15	46.07	122.01
W 5. 7	ELECTROPLATING	0.0	0.0	0.0	216.33	910.12
W 5. 8	COIL COATING	3.61	0.0	6.27	25.17	80.12
W 5. 9	PORCELAIN ENAMELING	3.01	0.0	5.99	28.94	85.82
	TOTAL ANNUAL COSTS	628.39	1353.34	1728.36	4099.24	8489.33

Chapter W5.1 Ore Mining and Dressing

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. In November 1982, EPA promulgated BAT, NSPS, and minor amendments to the existing BPT regulations. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the ore mining and dressing industry is not reflected in the text of the chapter or the cost estimates included in Table W5.1.1. The cost estimates represent the impact of the regulations as originally promulgated.

Industry Characteristics

The Ore Mining and Dressing Industry category is defined as including the mining, milling, and beneficiation of the following:

1) iron ore
2) copper ore*
3) lead/zinc ore*
4) gold ore*
5) silver ore*
6) bauxite ore
7) ferroalloys ore*
8) uranium, radium, and vanadium ores
9) titanium ore
10) platinum ore*
11) antimony ore*
12) mercury ore.

Regulations have been revoked for those subsectors marked with an asterisk. Compliance costs for those subsectors were based on meeting the equivalent of the revoked regulations.

The production of ore in the U.S. is closely associated with the rise and fall of the Gross National Product. Many subsectors have a small production rate in the U.S. due to competition with high grade foreign ores (e.g., ferroalloys) or environmental concerns (e.g., mercury). Gold and silver prospecting activity has increased and, since gold and silver are allowed to be sold on the open market now, mining activity may increase.

Iron Ore. There are presently a total of 58 iron ore mining operations (39 of these are major operations) in the United States that mine about 200 million metric tons (200 million long tons) of crude iron ore annually. These operations are located in the states of Wyoming, California, New York, Wisconsin, Alabama, Minnesota, Utah, Pennsylvania, Michigan, Texas, Georgia, Missouri and Colorado. Sixteen of these mines are in Minnesota and five are in Michigan--these account for the major part of the ore produced in the United States.

Copper Ore. Open pit mines produce 83 percent of the total copper output with the remainder of U.S. production coming from underground operations. Ten percent of the mined material is treated by dump (heap) and in-situ leaching. Recovery of copper from leach solutions by iron precipitation accounted for 87.5 percent of the leaching production; recover of copper by electro-winning amounted to 12.5 percent.

Lead and Zinc Ores. Lead and zinc ores are produced almost exclusively from underground mines. There are some deposits which are amenable to open pit operations; a number of mines during their early stages operated as open-pit mines and then developed into underground mines. The most common lead mineral mined in the U.S. is galena (lead sulfide). This mineral is often associated with zinc, silver, gold, and iron minerals. There are, however, numerous other minerals which contain zinc. The more common include sphalerite (zinc sulfide), zincite (zinc oxide), willemite (zinc silicate), and franklinite (an iron, zinc, manganese oxide complex). Sphalerite is often found in association with sulfides of iron and lead. Other elements often found in association with sphalerite include copper, gold, silver, and cadmium.

Silver Ore. Current domestic production of new silver is derived almost entirely from exploitation of low-grade and complex sulfide ores. Only one-fourth of this production is derived from ores in which silver is the chief value and lead, zinc, and/or copper are valuable byproducts. About three-fourths of the production is from ores in which lead, zinc, and copper constitute the principal values, and silver is a minor but important byproduct. Free-milling--simple, easily liberated--gold/silver ores, processed by amalgamation and cyanidation now contribute only 2 percent of the domestic silver produced.

Primary recovery of silver is largely from the mineral tetrahedrite, $(Cu, Fe, Zn, Ag)_{12}Sb_4S_{13}$. A tetrahedrite concentrate contains approximately 25 to 32 percent copper in addition to the 25.72 to 44.58 kilograms per metric ton (750 to 1300 troy ounces per short ton) of silver. A low-grade (3.43 kg per metric ton or 100 troy oz. per short ton) silver/pyrite concentrate is produced at one mill. Antimony may comprise up to 18 percent of the tetrahedrite concentrate and may not be extracted prior to shipment to a smelter.

Gold Ore. The domestic production of gold had been on a downward trend for the last 20 years, largely as a result of the reduction in the average grade of ore being mined and ore depletions at some mines. However, large increases in the free market price of gold during recent years has stimulated a widespread increase in prospecting and exploration activity.

In the United States, this industry is concentrated in eight states: Alaska, Montana, New Mexico, Arizona, Utah, Colorado, Nevada, and South Dakota.

Gold is mined from two types of deposits: placer and lode, or vein, deposits. Placer mining consists of excavating gold-bearing gravel and sands. This is currently done primarily by dredging but, in the past, included hydraulic mining and drift mining of buried placers too deep to strip. Lode deposits are mined by either underground or open-pit methods, the particular method chosen depending on such factors as the size and shape of the deposit, the ore grade, the physical and mineralogical character of the ore and surrounding rock, and the depth of the deposit.

Bauxite Ore. Bauxite mining, for the eventual production of metallurgical grade alumina, occurs in two operations near Bauxite, Arkansas. Both operations are associated with bauxite refineries, at which purified alumina (Al_2O_3) is produced. Characteristically, only a portion of domestic bauxite is refined for use in metallurgical smelting; one operation reports that only about 10 percent of the alumina it mines is smelted, while the remainder is destined for use as chemical and refractory grade alumina. A gallium byproduct recovery operation occurs in association with one bauxite mining and refining complex.

Ferroalloy Ores. The ferroalloy ore mining and milling category embraces the mining and beneficiation of ores of cobalt, chromium, columbium (niobium) and tantalum, manganese, molybdenum, nickel, and tungsten. SIC 1061, although presently including few operations and relatively small total production, covers a wide spectrum of the mining and milling industry as a whole. Sulfide, oxide, silicate, carbonate, and anionic ores all are, or have been, mined for the included metals. Open-pit and underground mines are currently being worked; placer deposits have been mined in the past and are included in present reserves. Operations vary widely in scale, from very small mines and mills intermittently worked with total annual production measured in hundreds of tons, to two of the largest mining and milling operations in the nation. Geographically, mines and mills in this category are widely scattered, being found in the southeast, southwest, northwest, north central, and Rocky Mountain regions. These operate under a wide variety of climatic and topographic conditions. Historically, the ferroalloy mining and milling industry production has undergone sharp fluctuations in response to variations of the prices of foreign ores, government policies, and production rates of other metals with which some of the ferroalloy metals in the U.S. are found. Ferroalloy ores in the U.S. are usually of lower grade (or more difficult to concentrate) than foreign ores and consequently are only marginally recoverable or uneconomic at prevailing prices. At present, ferroalloy mining and milling (with the exception of molybdenum) is being conducted at a very low level of production. Increased competition from foreign ores, the depletion of many of the richer deposits, and a shift in government policies from stockpiling materials to selling concentrates from stockpiles has resulted in the closure of most of the mines and mills that were active in the late 1950's. For some of the metals, there is little likelihood of further mining and milling in the foreseeable future; for others, increased production in the next few years is possible.

Uranium Ores. Uranium mining practice is conventional. Special precautions for the ventilation of underground mines reduce the exposure of miners to radon, a shortlived gaseous radioactive decay product of radium which can deposit daughter decay products in miners' lungs. Because of the small size of pockets of high-grade ore, open-pit mines are characterized by extensive development activity. At present, low-grade ore is being stockpiled for future use. Ore stockpiles on polyethylene sheets are heap-leached at several locations by percolation of dilute sulfuric acid through the ore. Because it is uneconomical to transport low-grade uranium ores very far, mines are closely associated with mills that yield a concentrate (yellowcake) containing about 90 percent uranium oxide. This concentrate is shipped to plants that produce compounds of natural and isotopically enriched uranium for the nuclear industry.

Titanium Ores. The principal mineral sources of titanium are ilmenite ($FeTiO_2$) and rutile (TiO_2). The United States is a major producer of ilmenite but not of rutile. Most of the U.S. mining of titanium ore occurs in New York and Florida.

Platinum Ores. The geologic occurrence of the platinum-group metals as lodes or placers dictates that copper, nickel, gold, silver, and chromium will be either byproducts or coproducts in the recovery of platinum metals, and that platinum will be largely a byproduct. With the exception of occurrences in the Stillwater Complex, Montana, and production as a byproduct of copper smelting, virtually all the known platinum-group minerals in the United States come from alluvial deposits in present or ancient stream valleys, terraces, beaches, deltas, and glaciofluvial outwash. The other domestic source of platinum is as a byproduct of refining copper from porphyry and other copper deposits and from lode and placer gold deposits, although the grade is extremely low.

Mercury and Antimony Ores. Mercury and antimony ore are currently produced at two respective mines in the U.S. Antimony production has fallen because of the state of the current market and availability of foreign supplies. Mercury production has increased due to the opening of a large mine in Nevada, currently the only significant mercury mining operation in the U.S.

Pollutants and Sources

Effluents are generally from two distinct sources: mine dewatering and ore-dressing operations (milling, washing, and separation of ore). The effluent from dressing operations is usually higher in suspended solids. Effluents from this industry are generally high in suspended solids, dissolved metals (depending on the solubility of the specific ores), and small quantities of flotation and flocculation reagents. The suspended solids result from the opening of geological structures to seepage and erosion, and from the milling of the ore for beneficiation.

Control Technology

The wastewaters are generally discharged to a tailings or settling pond in which the suspended solids are allowed to settle. A portion of the water is recycled if possible, and a portion discharged. Raw tailings wastewater contains on the order of 70,000 to 500,000 mg/l suspended solids. The settling rates of solids in tailing ponds vary.

Ninety-eight percent of the solids settle rapidly. However, graillaceous materials present in raw ore and fines produced in grinding operations settle very slowly.

The principal method of water effluent treatment consists of settling ponds. Almost all mines and beneficiation plants use settling ponds and recycle water. The wastewater currently discharged could be treated by further retention to reduce the suspended solids content. The retention times in many of these pond systems, however, are not sufficient to reduce the level of suspended solids adequately, particularly during periods of heavy surface run-off. The basic differences between the operation of present tailings systems and that proposed as BPT are the increased retention time achieved by additional ponds, or clarifiers, coagulation flocculation systems, and the use of lime neutralization. Some cases will require the destruction of cyanides and the selective precipitation of specific metals. Where settling ponds are not sufficient, filters can be used to augment treatment.

Costing Methodology

Table W5.1.1 contains a summary of BPT compliance costs for all the above categories of ore mining, based on the models and costs identified in the Guidelines Development Document for the 1975 Interim Final Rulemaking.

Table W5.1.1. Ore mining and dressing

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.349E+08 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	455.30	212.61	212.61	0.0
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	87.81	115.74	254.00	517.44	878.13
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	77.87	106.21	232.76	466.36	778.68
ANNUAL CAPITAL + O+M	165.68	221.95	486.76	983.80	1656.81
ALL ANNUAL COSTS	165.68	221.95	486.76	983.80	1656.81

Chapter W5.2 Iron and Steel

Regulations

Promulgated regulations have established effluent limitations guidelines for best practicable technology (BPT) and best available technology (BAT), performance standards for new sources (NSPS) and pretreatment standards for new and existing sources (PSNS, PSES) for firms in the iron and steel manufacturing point source category. These final regulations were published in the Federal Register on May 27, 1982. These regulations contained specific guidelines and standards for twelve subcategories of the iron and steel industry. These subcategories are:

A. Cokemaking
B. Sintering
C. Ironmaking
D. Steelmaking
E. Vacuum Degassing
F. Continuous Casting
G. Hot Forming
H. Scale Removal
I. Acid Pickling
J. Cold Forming
K. Alkaline Cleaning
L. Hot Coating

Industry Characteristics

The manufacture of steel involves many processes which require large quantities of raw materials and other resources. The iron and steel production processes can be segregated into two major components: basic steelmaking; and forming and finishing operations.

In the first major process, coal is converted to coke which is then combined with iron ore and limestone in a blast furnace to produce crude iron (pig iron or cast iron). The crude iron is then converted into steel in either open hearth, basic oxygen or electric arc furnaces. Finally, the steel can be further refined by vacuum degassing.

Following the steelmaking processes are the hot forming (including continuous casting) and cold finishing operations. Hot forming primary mills reduce steel ingots to slabs or blooms and secondary hot forming mills reduce slabs or blooms to billets, plates, shapes, strip, and various other products. Steel finishing operations involve a number of other processes that do little to alter the dimensions of the hot rolled product, but which impart desirable surface or mechanical properties.

The steel industry is included within the United States Department of Commerce, Bureau of Census Standard Industrial Classification (SIC) Major Group 33 - Primary Metal Industries. The parts of the industry covered by the regulations are the SIC subgroups - 3312, (except coil coating), 3315, 3316, and 3317. These include all processes, subprocesses and alternate processes involved in the manufacture of intermediate or finished products in the above categories.

Steel facilities range from comparatively small plants engaging in one or more production processes to extremely large integrated complexes engaging in several or all production processes. Even the smallest steel facility, however, represents a fairly large industrial complex. The Agency estimates that there are about 680 plant locations containing over 2,000 individual steel making and forming and finishing operations. The 1980 revenues of the United States steel industry were about 72 billion dollars and total employment was approximately 570,000 employees. The fifteen largest steel corporations provided approximately 87 percent of the total annual U.S. steel ingot production.

Domestic steel shipments in 1981 were estimated to be about 87 million tons, an increase of 3.7 percent over the depressed level of 83.9 million tons in 1980, when the high interest rates that curbed demand in major steel-consuming sectors, as well as the relative cost advantage of foreign steel, kept shipments at low levels. Because of uncertainty surrounding future domestic steel shipments, the Economic Impact Report derived two growth scenarios for domestic steel shipments and analyzed the economic impacts of wastewater pollution control regulations under both scenarios. This chapter presents the costs associated with growth scenario 1 in which the industry is assumed to recover from the current recession by 1982 and grow at an annual rate of 2 percent through 1990.

Pollutants and Sources

Water is essential to the iron and steel industry and is used in appreciable quantities in virtually all process operations. An average of 40,000 gallons of water is used in the production of every ton of finished steel, making the industry one of the highest water users of any manufacturing industry.

Total process water usage in the steel industry is about 5,740 million gallons per day. The untreated process wastewaters contain about 43,600 tons per year of toxic organic pollutants, 121,900 tons per year of toxic inorganic pollutants and 14.5 million tons per year of conventional and nonconventional pollutants.

The following wastewater pollutants have historically been regulated in the steel industry: Suspended solids, oil and grease, ammonia-N, cyanide, phenols, fluoride, iron, total and hexavalent chromium, tin, lead, and zinc. Other pollutants are found in the industry's wastewaters; however, the Agency did not limit these pollutants in the regulations because the technology for their removal is presently considered beyond the scope of BPT and BAT for the industry.

Control Technologies

Many different wastewater treatment technologies are currently employed in the iron and steel industry. Generally, primary wastewater treatment encompasses physical/chemical methods of treatment, including neutralization, sedimentation, flocculation and filtration. Treatment for toxic pollutants requires advanced technologies such as biological treatment, carbon adsorption, ion exchange, reverse osmosis, and sophisticated chemical techniques.

Within the cokemaking subcategory, organic pollutant removal is accomplished by biological treatment in bio-oxidation lagoons and activated sludge plants; and, physical/chemical treatment in ammonia stills, dephenolizers and activated carbon systems. Sedimentation and filtration are also used in this subcategory.

Treatment facilities at plants in the sintering, ironmaking and steelmaking subcategories rely heavily upon flocculation, sedimentation and recycling of treated wastewaters. Clarifiers and thickeners are principally used in connection with polymers and coagulants such as lime, alum, and ferric sulfate.

Wastewaters from nearly all hot forming operations are treated in scale pits followed by lagoons, clarifiers, filters, or combinations thereof. Polymers and coagulants such as lime, alum, and ferric sulfate are normally used in conjunction with clarifiers. The filters employed are usually either gravity or pressure type with sand or other media.

Treatment techniques at cold finishing operations include equalization prior to further treatment; neutralization with lime, caustic or acid; flocculation with polymers; and, sedimentation. Central or combined treatment systems are common for these operations.

Advanced control measures for the toxic pollutants include two-stage (i.e. extended) biological treatment (cokemaking); granular activated carbon; powdered carbon addition; pressure filtration; pressure filtration accompanied with sulfide addition; and, multi-state evaporation/condensation systems.

A summary of the model treatment system by subcategory and a more detailed description of the systems are presented in the appendix.

Costing Methodology

The water pollution control compliance costs for the iron and steel industry were obtained exogenously from the Economic Analysis Report. The costs of compliance for the iron and steel industry are presented in Table W5.2.1.

Table W5.2.1. Iron and steel

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	134.26	1537.91	461.13	937.30	896.48
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	262.82	806.20	729.71	1638.31	2971.56
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	120.69	141.46	295.35	765.77	1920.44
ANNUAL CAPITAL + O+M	383.51	947.67	1025.06	2404.08	4892.00
ALL ANNUAL COSTS	383.51	947.67	1025.06	2404.08	4892.00

Chapter W5.3 Ferroalloy Industry

Regulations

BAT regulations for the industry covered in this chapter are currently under review by EPA. It is anticipated that the review may result in some change in the regulations, with subsequent effects on the estimated cost of compliance. Because of possible changes in the BAT regulations following the review, this chapter has not been updated. The costs shown here are based on documentation associated with the regulations as originally promulgated, and the costs for compliance with BAT are subject to change if the BAT regulations are modified.

Industry Characteristics

The ferroalloy industry produces most of its products through electric-furnace smelting, exothermic refining, and electrolytic processing.

The products of electric-furnace smelting and/or exothermic refining include such products as ferrosilicon, silicon metal, ferromanganese, silicomanganese, ferromanganese-silicon, ferrochromium, ferrochrome-silicon, calcium-silicon, ferrotitanium, ferrovanadium, ferrocolumbium, and silicomanganese-zirconium. The products of the electrolytic process are primarily manganese, manganese dioxide, and chromium.

Since electric-furnace smelting is also the manufacturing process for calcium carbide, and the largest producers of calcium carbide are ferroalloy companies, calcium carbide is considered with the ferroalloy industry (rather than the inorganic chemicals industry) for pollution abatement consideration. The products of the ferroalloy industry are classified in SIC 3313 (Electrometallurgical Products); calcium carbide appears in SIC 2819 (Industrial Inorganic chemicals, Not Elsewhere Classified).

Pollutants and Sources

For purposes of establishing water effluent limitation guidelines and standards of performance, the industry has been divided into the following categories:

- Ferroalloy Smelting and Refining Segment
  -Open Electric Furnaces with Wet Air Pollution Control Devices
  -Covered Furnaces and Other Smelting Operations with Wet Air Pollution Control Devices
  -Slag Processing

- Calcium Carbide Segment
  - -Covered Calcium Carbide Furnaces with Wet Air Pollution Control Devices
  - -Other (i.e., Open) Calcium Carbide Furnaces

- Electrolytic Segment
  - -Electrolytic Manganese
  - -Electrolytic Manganese Dioxide
  - -Electrolytic Chromium

Most of the water usage by this industry is for noncontact cooling purposes. From 700 to 5000 gallons per minute (or 3,000 to 11,000 gallons per megawatt-hour) may be used to cool the furnace and components of the electrical systems. The largest source of water-borne pollutants in the ferroalloy smelting and refining segment and the calcium carbide segment is related to the use of wet methods (e.g., wet scrubbers and precipitators) to control air pollution. Scrubbers are the principal wet air pollution control device (APCD) presently used in the industry. Scrubber water usage ranges from about 500 to 3500 gallons per megawatt-hour.

The ferroalloy and calcium carbide segments are further divided and categorized based upon the furnace operation being of the open or closed type. In the open furnace operation, the carbon monoxide rich off-gas is combusted at the top of the furnace mix and the burned gases plus excess air are subsequently ducted to the air pollution control device. In the closed-type operation, the furnace is covered to exclude air from the furnace interior. However, as the closed furnace gases to be cleaned are uncombusted, they contain components such as cyanide and phenols, which are not found in appreciable amounts in the open-furnace off-gases. Additional water treatment is required for the effluent from wet air pollution control devices (APCD) serving closed furnaces.

Slag processing is an additional source of water pollution in several of the ferroalloy plants. As it represents an additional source of water pollution, slag processing is introduced as a separate subcategory. Thus, in the case of the ferroalloy and calcium carbide smelting and refining segments, the preferred categorization factor for water effluent considerations is the type of furnace equipment (i.e., open or closed furnace, dry or wet APCD) and the auxiliary processing (i.e., slag processing) utilized.

The preferred basis for water effluent characterization and treatment for the electrolytic segment of the industry is by product, i.e., manganese (Mn), manganese dioxide (MnO_2) or chromium (Cr).

It should be noted and appreciated that many of the large ferroalloy plants have concurrent in-plant operations which fall in several of the water effluent categories and subcategories. Thus, as proposed by EPA, the water guidelines and performance standards may be applied to specific plants on the basis of a "building block" or unit operation approach, with the total plant effluent limitations based on the summation of each pollutant in each category. The same approach is taken for costing the required water treatment systems for a multi-operation plant. As expected, the costs associated with the treatment of a particular plant's wastewater are best determined through detailed engineering and cost analysis for the specific plant and operation.

Control Technology

The water pollutants to be controlled for each segment are presented in Table W5.3.1. The achievement of BPT limitations for all segments is based upon physical/chemical treatments, while BAT limitations require physical/chemical treatment plus partial recycle of water.

Table W5.3.1. Ferroalloy industry pollutants

Open electric furnaces with air pollution control devices	TSS Chromium total Chromium VI Manganese total
Covered electric furnace and other smelting operations with wet air pollution control devices	TSS Chromium total Chromium VI Manganese total Cyanide total Phenols
Slag processing	TSS Chromium total Manganese total
Closed calcium carbide furnace	TSS Cyanide
Electrolytic manganese	TSS Manganese Chromium NH_3-N

Costing Methodology

The estimates of water pollution control costs reported here were developed on the basis of a plant-by-plant review to determine the type of air pollution control device (wet or dry) in use, and the use of published costs of water pollution control for some specific plants. Where published data were not available, engineering estimates of costs based on cost factors from Guidelines Development Documents were applied. The costs listed in Table W5.3.2 are largely those of the portion of the industry using wet air pollution control devices.

Table W5.3.2. Ferroalloy industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .103E+08

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.32	28.69	1.83	5.13	6.14
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.01	13.30	11.66	24.56	40.48
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	8.41	21.37	25.23	53.61	99.91
ANNUAL CAPITAL + O+M	12.42	34.67	36.88	78.16	140.40
ALL ANNUAL COSTS	12.42	34.67	36.88	78.16	140.40

Chapter W5.4 Bauxite Refining Industry

Regulations

The regulations for BPT, BAT, and NSPS are essentially zero discharge of process wastewaters to navigable waters (39 FR 12811, April 8, 1974).

In addition there is a pretreatment standard for new bauxite plants (40 CFR 421) which calls for the treatment of incompatible pollutants except that if the publically owned treatment works is committed to remove some percentage of any incompatible pollutant, then the bauxite refinery may be less stringent in its treatment.

Industry Characteristics

There are nine bauxite refineries in the United States; one of the plants is located at St. Croix, Virgin Islands. Modest capacity increases are believed to be occurring by minor process changes that do not in reality constitute a new source with respect to emission control. These plants produce alumina from bauxite which is subsequently used in the manufacture of aluminum. Although the refineries are categorized as being a part of the Miscellaneous Inorganic Chemicals Industry, Not Elsewhere Classified (SIC 2819), they are integral with the Primary Aluminum Industry.

Pollutants and Sources

Major pollutants arising from a bauxite refinery are the suspended solids and dissolved solids contained in the discharged waste in "red mud" after the alumina values have been leached from bauxite. Although other pollutants are produced, the relative magnitude of the problems imposed are incidental.

Control Technology

Total impoundment of the red mud and all other process wastewaters was proposed by the regulations to achieve zero discharge of all pollutants. Liquids are recycled to the refineries while the red mud solids settle in the impoundment areas.

Costing Methodology

Empirical cost data based on the plant-by-plant analysis in the Development Document were used in costing because several of the plants were already impounding either their total flow or the red mud slurries before the Act and, thus, a model plant combined with cost function methodology was not appropriate. All plants within the contiguous United

States were included in the costs. Total industry costs (in 1973 dollars) for capital were 52.8 million and for annual operating were 5.64 million per year.

Costs are tabulated in 1981 dollars in Table W5.4.1.

Table W5.4.1. Bauxite refining industry

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS)					
CAPITAL IN PLACE (KIP):	.129E+07				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	98.14	0.0	0.0	0.0
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	12.90	45.16	38.71	77.41	119.35
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10.61	37.12	31.82	63.63	106.05
ANNUAL CAPITAL + O+M	23.51	82.28	70.52	141.04	225.40
ALL ANNUAL COSTS	23.51	82.28	70.52	141.04	225.40

Chapter W5.5 Primary Aluminum Smelting Industry

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. In January 1983, EPA proposed new regulations for BAT, NSPS, BCT, and PSNS. EPA did not propose a PSES regulation because there are no indirect dischargers. BPT was not revised. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the primary aluminum smelting industry is not reflected in the text of the chapter or the cost estimates included in Table W5.5.1. The cost estimates represent the impact of the regulations as originally promulgated.

Industry Characteristics

The primary aluminum industry has three production stages: bauxite mining, bauxite refining to produce alumina (aluminum oxide), and the reduction of alumina to produce aluminum metal; this last state is commonly known as aluminum smelting.

The reduction of alumina to produce aluminum metal is carried out in electrolytic cells, or pots, that are connected in series to form a potline. The facility containing a number of potlines is referred to as the potroom. The electrolysis takes place in a molten bath composed principally of cryolite, which is a double fluoride of sodium and aluminum. Alumina is added to the bath periodically. As electrolysis proceeds, aluminum is deposited at the cathode, and oxygen is evolved at the carbon anode. The oxygen reacts with the carbon to produce a mixture of carbon monoxide and carbon dioxide while the anode is consumed.

Two methods of replacing the anodes are practiced; these are referred to as the prebaked anode (intermittent replacement) and the Soderberg anode (continuous replacement). For either system, the anode preparation begins in the anode paste plant, where petroleum coke and pitch are hot-blended. For prebaked anodes, the anode paste is pressed in molds, and the anodes are baked in the anode bake plant. The baked anodes are used to replace consumed anodes, and the anode butts are returned to the anode preparation area. In the Soderberg anode system, the anode paste is not baked initially, but is fed continuously through a tubular steel sleeve into the pot. As the paste approaches the hot bath, the paste is baked in place to form the anode. Soderberg anodes are supported in the sleeves by vertical or horizontal studs.

The continuous evolution of gaseous reaction products from the aluminum reduction cell yields a large volume of fumes that require ventilation systems for removal from the potroom. The ventilation air must be scrubbed to minimize air pollution and both dry and wet scrubbing methods are used for this purpose. Water from wet scrubbers, used for air pollution control on potroom ventilation air, is the major source of wastewater in the primary aluminum industry.

The liquid aluminum produced is tapped periodically, and the metal is cast in a separate cast-house facility. The molten metal is degassed before casting by bubbling chlorine or a mixed gas through the melt. The chlorine degassing procedure also produces a fume which must be scrubbed for air pollution control.

A few aluminum smelters have metal fabrication facilities, such as rod mills, rolling mills, etc., on the primary reduction plant site. Since these metal fabrication operations will be covered under separate effluent limitations, they are not covered by this report.

Pollutants and Sources

As mentioned previously, the major source of wastewater in the primary aluminum smelting industry is the water used in air pollution control equipment (scrubbers) that are installed on potline and potroom ventilation air systems. Scrubbers are also used on anode bake furnace flue gas, and on cast-house gases. Other significant sources of wastewater include: cooling water used in casting, rectifiers, and fabrication; boiler blowdown; and storage area run-off, especially water contaminated with fluoride from spent cathodes.

Significant pollutants from the primary aluminum smelting industry for the purposes of establishing effluent limitations guidelines are: fluoride, total suspended solids, and pH. Other wastewater pollutants identifiable with the industry, but not considered significant, include: oil and grease, cyanide, dissolved solids, chloride, sulfate, chemical oxygen demand, temperature, and trace metals.

Control Technology

BPT includes the treatment of wet scrubber water and other fluoride-containing effluents to precipitate the fluoride, followed by settling of the precipitate and recycling of the clarified liquor to the wet scrubbers. A holding pond or lagoon might also be necessary to minimize the discharge of suspended solids. Precipitation methods currently available use lime. Alternate control technologies which can be employed to achieve the required effluent levels include dry fume scrubbing, total impoundment, and reuse of effluent water by a companion operation.

The application of the BPT described above results in a relatively low-volume, high-concentration bleed stream from the recycling system. BAT is lime or calcium chloride precipitation treatment of the bleed stream to further reduce the discharge of fluorides. Use of this technology assumes that the volume of fluoride-containing effluent is reduced to approximately 5,000 liters per metric ton (1,200 gallons per short ton) of aluminum. Alternatively, volumes as high as 50,000 liters per metric ton (12,000 gallons per short ton) may be possible if the effluent is treated by absorption methods (activated alumina or hydroxyapatite).

NSPS technology assumes the application of dry fume scrubbing systems or, alternatively, wet scrubbing equipment together with total impoundment or total recycling of the scrubber water. The treatment for fluoride and suspended solids removal is essentially the same as for BPT above. The NSPS require the restriction of the discharge volume to 835 liters per metric ton (200 gallons per short ton) of aluminum with a final fluoride concentration of 30 mg per liter; or an equivalent combination of fluoride level and volume. Alternatives for reducing water use and pollutant levels include air-cooled, solid state rectifiers; non-chemical methods of molten metal degassing; and careful cleaning of the anode butts before recycling.

Approximately two-thirds of the primary aluminum smelting plants in the United States are currently operating with discharge levels of pollutants within the July 1977 guidelines.

Costing Methodology

Nationwide costs of the primary aluminum smelting industry were estimated from model plant costs and are summarized in Table W5.5.1. Model plant numbers and sizes, compliance costs and other data were taken from the Development Document. No costs are indicated for new sources as new plants are using the dry gas-scrubbing process which uses no water in the control of pollutants.

Table W5.5.1. Primary aluminum smelting industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .107E+09

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	49.97	0.50	0.50	11.81
BAT	8.57	0.0	25.70	34.26	17.13
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	8.57	49.97	26.20	34.77	28.94
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	6.64	18.52	19.84	39.75	66.15
BAT	3.38	0.0	6.76	20.27	43.92
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10.01	18.52	26.60	60.02	110.07
O + M					
EXISTING PLANTS					
BPT	12.69	35.39	37.93	75.99	180.77
BAT	6.61	0.0	13.21	39.63	85.87
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	19.29	35.39	51.14	115.62	266.63
ANNUAL CAPITAL + O+M	29.31	53.91	77.74	175.64	376.70
ALL ANNUAL COSTS	29.31	53.91	77.74	175.64	376.70

Chapter W5.6 Secondary Aluminum Smelting Industry

Regulations

Regulations affecting this industry were revised under the provisions of the NRDC Consent Decree. In January 1983, EPA proposed new regulations for BAT, NSPS, PSES, and PSNS. BPT was not revised. However, revision of this chapter was limited to adjusting pollution control costs to 1981 dollars. The effect of any changes in the regulations affecting the secondary aluminum smelting industry is not reflected in the text of the chapter or the cost estimates included in Table W5.6.1. The cost estimates represent the impact of the regulations as originally promulgated.

Industry Characteristics

The secondary aluminum industry comprises an estimated 54 firms with 66 plants. Other sources list the industry as having more plants, but these numbers include sweaters, scrap dealers, and non-integrated fabricators. For purposes of this report, the number of plants reported excludes these portions of the industry as they do not employ any of the processes included in the effluent limitations guidelines.

The secondary aluminum smelting industry is a subcategory of the aluminum segment of the nonferrous metals manufacturing category. This subcategory recovers, processes, and remelts various grades of aluminum-bearing scrap to produce metallic aluminum or an aluminum alloy as a product. This product is used primarily to supply the following industries: construction, aircraft, automotive, electrical equipment, beverage cans, and fabricated metal products (which includes a wide variety of home consumer products). The largest user of secondary aluminum ingot is the automotive industry.

Secondary aluminum ingot is produced to specifications; melting to specification is achieved mainly by segregating the incoming scrap into alloy types. The magnesium contained in the scrap is removed, as desired, by a chlorine-gas treatment (demagging) in a reverberatory furnace.

Pollutants and Sources

Wastewaters are generated by the following processes: (1) ingot cooling and shot quenching, (2) scrubbing of furnace fumes during demagging, and (3) wet milling of residues or residue fractions.

The following are the primary wastewater pollutants discharged by the above processes: oil and grease, suspended and dissolved solids, and salts of aluminum and magnesium.

In metal cooling, molten metal in the furnace is usually either cast into ingot or smaller (sow) molds or is quenched into shot. Ingot molds are sprayed while on conveyor belts to solidify the aluminum and allow its ejection from the mold. Shot is solidified by having metal droplets fall into a water bath. The wastewater generated is either vaporized, discharged to municipal sewerage or navigable waters, recycled for some period and discharged (6-month intervals), continuously recycled with no discharge, or discharged to holding ponds.

Fume scrubbing is necessitated when aluminum scrap contains a higher percentage of magnesium than is desired for the alloy produced. Magnesium removal, or "demagging", is done either by passing chlorine through the melt (chlorination) or with aluminum fluoride. When magnesium is extracted, heavy fuming results; this requires passing the fumes through a wet scrubbing system. Water used in scrubbing picks up pollutants, primarily in the scrubbing of chlorine demagging fumes.

Residue processing takes place in the industry since residues are composed of 10 to 30 percent aluminum, with attached aluminum oxide fluxing salts (mostly NaCl and KCl), dirt, and various other chlorides, fluorides, and oxides. The metal is separated from the non-metals by milling and screening (which is performed either wet or dry). In wet milling, the dust problem is minimized but the resulting waste stream is similar in make-up to scrubber waters but more concentrated in dissolved solids.

Pollutant parameters for wastewater from wet milling of residues include total suspended solids, fluorides, ammonia, aluminum, copper, COD, and pH. Pollutant parameters for wastewater from fume scrubbing include total suspended solids, COD, and pH.

Control Technology

Approximately 10 percent of the industry is currently discharging directly to navigable waters. The majority of the industry discharges effluents to municipal treatment works, usually with some pretreatment.

Currently, some plants are utilizing various control alternatives for each of the three major wastewater sources. The control technologies required to meet BPT and BAT are as follows:

BPT. Metal Cooling. Air cooling or continuous recycling of cooling water with periodic removal, dewatering, and disposal of sludge.

Fume Scrubbing. Chlorine Fume Scrubbing (for magnesium removal using chlorine): pH adjustment and settling. Fluoride fume scrubbing (for magnesium removal using aluminum fluorides): pH adjustment, settling, and total recycling.

Residue Milling. Adjustment of pH with settling and water recycle.

BAT. Metal Cooling. Air cooling, water cooling (for complete evaporation), and total use and recycle of cooling water by use of settling and sludge dewatering.

Fume Scrubbing. Use of aluminum fluoride for magnesium removal, and entrapment of fumes without major use of water, using alternatives such as the Alcoa process, Derham process or the Tesisorb process.

Residue Milling. Dry milling, and a water recycle evaporation and salt reclamation process.

Costing Methodology

The costs for compliance were developed on the basis of the plant numbers, sizes, processes, air pollution control status, and treatment and discharge status as given in the Development and Economic Analysis Documents published in 1974. Three cost sectors were modeled: one for each of the three operations generating wastewaters; the models thus reflect the population of these unit operations rather than the total number of plants. The aggregate costs of compliance developed on this basis are given in Table W5.6.1.

Table W5.6.1. Secondary aluminum smelting industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .488E+07

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	5.78	0.06	0.06	1.37
BAT	0.59	0.0	1.77	2.37	1.18
NEW PLANTS (NSPS)	1.00	3.78	2.83	7.08	23.56
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.59	9.56	4.66	9.51	26.11
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.77	2.14	2.30	4.60	7.65
BAT	0.23	0.0	0.47	1.40	3.03
NEW PLANTS (NSPS)	0.87	1.44	2.22	5.81	20.40
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.87	3.58	4.98	11.81	31.08
O + M					
EXISTING PLANTS					
BPT	2.04	5.70	6.10	12.23	23.00
BAT	1.23	0.0	2.45	7.36	15.94
NEW PLANTS (NSPS)	2.20	3.62	5.61	14.69	52.02
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	5.47	9.32	14.17	34.28	90.96
ANNUAL CAPITAL + O+M	7.34	12.90	19.16	46.09	122.05
ALL ANNUAL COSTS	7.34	12.90	19.16	46.09	122.05

Chapter W5.7 Electroplating and Metal Finishing Industry

Regulations

The regulations analyzed in this chapter are based on the final rule amendments promulgated on January 28, 1981 and new proposed regulations on August 31, 1982, specifying pretreatment standards for existing sources (PSES) of the Electroplating Point Source Category and BPT, BAT, NSPS, PSES, and PSNS for the Metal Finishing Point Source Category. The effluent limitations guidelines for BPT for the electroplating industry were suspended indefinitely on December 3, 1976 and were then revoked on January 28, 1981. In addition, the effluent limitations guidelines for BAT, new source performance standards (NSPS) and pretreatment standards for new sources (PSNS) for the industry were revoked on December 3, 1976.

Under the regulations which were proposed on August 31, 1982, the PSES guidelines which were promulgated January 28, 1981, will apply to all indirect discharging electroplaters. All electroplating facilities, other than indirect discharging job shops and independent printed circuit-board manufacturing, will subsequently be subject to the regulations for Metal Finishing point source category and will comply with regulations proposed for this category.

Industry Characteristics

The Electroplating and Metal Finishing Categories consist of 13,000 plants. These establishments apply surface treatments by electrolytic deposition and other methods. The treatments provide corrosion protection, wear or erosion resistance, antifrictional characteristics, lubricity, electrical conductivity, heat and light reflectivity, or other special surface characteristics.

In the economic impact analyses, the universe of electroplating and metal finishing firms was defined in terms of the following three production sectors:

- Job shops--Independent operations performing the metal finishing processes covered by the regulations as their primary line of business.
- Printed board manufacturers--Independent producers of wire or circuit boards whose products involve copper and electroless plating.
- Captive shops--Production centers, found within manufacturing firms, that provide finishing services to the products of the parent company.

The number of plants by category are presented in Table 5.7.1.

Table W5.7.1

Job shops and IPCBM* (3470)	Nonintegrated	Integrated
Indirect dischargers (10,561):		
3061	3,750	3,570
Job & IPCBM	Nonintegrated	Integrated
Indirect	Captive	Captive
Direct Dischargers (2,909):		
409	2,500	
Job & IPCMB	Captive	
Directs	Directs	

*Independent Printed Circuit Board Manufacturers.

Independent job shops are classified in SIC 3471 (Plating and Polishing) and 3479 (Metal Coating and Allied Services, n.e.c.). Firms in SIC 3471 are major consumers of common plating metals (i.e., copper, zinc, nickel, chromium) whereas firms in SIC 3479 are distinguished by their technical production processes (anodizing, phosphating, precious metal plating, etching, etc.). Output charges in real constant dollars (1982) increased to $3.2 billion in 1979 from $2.16 billion in 1972 for a growth rate of 5.8 percent per year.

Printed board manufacturers, which are classified in SIC 3679 (electronic components, n.e.c.) had a value of $1.5 billion in 1980. A growth rate of 20 percent per year was assumed based on projected trends of the U.S. semiconductor industry.

Captive operations are classified in SIC 34 through 39. Average plant sales of metal finished goods was approximately $10.9 million in 1976 according to the most relevant information sources. Total industry sales are approximately $109 billion, of which $11 billion or 10 percent of sales account for the total value added by metal finishing. Annual growth in the industry is expected to amount to 3 percent per year.

Pollutants and Sources

Wastewater from this industry comes from pretreatment and post-treatment operations as well as the actual metal finishing and electroplating steps. Table W5.7.2 lists the major types of wastes generated by these operations. The known significant pollutants and pollutant properties from these operations include pH, total suspended solids, cyanide, chromium, copper, nickel, zinc, cadmium, lead, aluminum, and various precious metals and organic compounds. The present EPA study indicates that many of these pollutants may occur together and that their individual concentrations may exceed 100 mg/l.

Wastewater results from the following operations in this industry: rinsing to remove films of processing solution from the surface of work pieces at the site of each operation; rinsing away spills; scrubbing ventilation exhaust air; dumping of spent solutions; washing of equipment; and discharging cooling water used in heat exchangers to cool solutions in metal finishing processes.

Approximately 90 percent of the water consumed is in rinsing. That used as cooling water is usually recycled for rinsing.

Many of the pollutants which are generated are toxic pollutants which have potential for environmental or POTW damage. Therefore, the most important pollutants associated with the electroplating industry which are controlled by PSES regulations are:

1. Toxic pollutants--cyanide, lead, cadmium, copper, nickel, chromium, zinc, silver, and toxic organics (lumped together as total toxic organics); and

Table W5.7.2. Major wastes and their sources generated by the electroplating and metal finishing industry

Waste	Source
Proprietary solutions	These are mainly cleaners or plating process accelerators of various types of which the chemical composition is proprietary.
Catalysts and accelerators	In electroless plating on plastics, a catalyst must be applied to the plastic to initiate the plating process. The catalyst consists of tin and palladium, and in the acceleration process the tin is removed. A chromic acid surface preparation of the plastic usually precedes the catalyst application.
Concentration acid and pickling waste	Originate primarily from stripping and cleaning of metal. Usually contain one or more of the following: hydrochloric acid (most common), sulfuric acid, nitric acid, chromic acid, fluoroboric acid, and phosphoric acid. The solution compositions vary according to the nature of the base metals and the type of tarnish or scale to be removed. These acid solutions accumulate appreciable amounts of metal as a result of dissolution of metal from work pieces or uncoated areas of plating racks that are recycled repeatedly through cleaning, acid treating, and electroplating baths. As a result, the baths usually have a relatively short life, and when they are dumped and replaced, large amounts of chemicals must be treated or reclaimed. These chemicals also enter the waste stream by way of dragout from the acid solutions into rinse waters.
Strong acid rinse waters	From rinsing after acid dips, pickling solutions, and strong acid process solutions.
Concentrated alkalies	Cleaning solutions usually contain one or more of the following chemicals: sodium hydroxide, sodium carbonate, sodium meta-[2] silicate, sodium phosphate (di- or trisodium), sodium silicate, sodium tetra phosphate, and a wetting agent. The specific content of cleaners varies with the type of soil being removed. For example, compositions for cleaning steel are more alkaline and active than those for cleaning brass, zinc die castings, and aluminum. Waste waters from cleaning operations contain not only the chemicals found in the alkaline cleaners but also soaps from the saponification of greases left on the surface by polishing and buffing operations. Some oils and greases are not saponified but are, nevertheless, emulsified. The raw wastes from cleaning process solutions and dissolution of basis metals show up in the rinse waters, spills, dumps of concentrated solutions, wash waters from air-exhaust ducts, and leaking heating or cooling coils and heat exchangers. The concentrations of dissolved basis metal in rinses following alkaline cleaning are usually small relative to acid dip rinses.
Cyanide concentrates	Includes cyanide plating solutions and cyanide plated or dipped metal parts.
Chromates	Originate from both plating and rinsing of metals that have been treated with chromate solutions.

(Ref. 1, 8).

2. Conventional pollutants--TSS and pH. (Note: These pollutant parameters are optional.)

Control Technologies

The two general approaches to removing or recovering wastewater pollutants generated by plating, metal finishing, and printed board manufacturing processes are in-plant technologies and end-of-pipe treatment technologies.

The intent of in-plant technology for the overall Electroplating and Metal Finishing Point Source Category is to reduce or eliminate the waste load requiring end-of-pipe treatment and, thereby, improve the efficiency of waste treatment. In-plant technology involves the selection of rinse techniques, plating bath conservation, good housekeeping practices, recovery and/or reuse of plating and etch solutions, and process modification.

For metal finishers, precipitation and clarification of effluents has been proposed for compliance with BPT. In addition, for cyanide or hexavalent chromium the technology basis incorporates techniques to destroy cyanide and reduce hexavalent chromium to trivalent chromium. This technology is the same as that promulgated for PSES for electroplaters. BAT for metal finishers is proposed as the same as BPT limitations for metal finishers. PSES is also the same as BPT.

BPT plus in-plant control of cademium is proposed for NSPS. PSNS is proposed as equivalent to NSPS.

Costing Methodology

Water pollution control costs for compliance with PSES electroplating industry and BPT/BAT and PSNS/PSES for the metal finishing industry were obtained exogenously from the August 31, 1982 Federal Register. Capital cost estimates are based on the total cost of equipment that EPA estimates will enable a discharger to meet the regulations. The O&M costs were estimated by subtracting the estimated capital recovery costs from the annual costs presented in the Federal Register where all costs were expressed in 1982 dollars.

Estimated abatement costs are summarized in 1981 dollars in Table W5.7.3.

Table W5.7.3. Electroplating and metal finishing industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	662.33	785.27
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	193.46	812.91
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	22.87	97.21
ANNUAL CAPITAL + O+M	0.0	0.0	0.0	216.33	910.12
ALL ANNUAL COSTS	0.0	0.0	0.0	216.33	910.12

Chapter W5.8 Coil Coating

Regulations

The coil coating industry, which coats large rolls or "coils" of flat metal with various types of organic polymer coatings and laminates to give the metal decorative or protective qualities, has not been included in previous Cost of Clean reports. The regulations proposed for this industry establish effluent limitations guidelines for BPT and BAT, pretreatment standards for new and existing sources (PSES, PSNS) and performance standards for new sources (NSPS) (Ref. 2). The proposed regulations do not require the installation of any particular treatment technology. Rather, they require achievement of effluent limitations through the proper operation of demonstrated control technologies or through control technologies that achieve an equivalent reduction.

Industry Characteristics

EPA developed two sets of subcategories for the coil coating industry. The first set which was devised for promulgating regulations was based upon the type of metal coated (i.e., aluminum, cold and rolled steel, and galvanized steel). since most plants in the industry are capable of coating more than one type of metal, the first subcategorization scheme was inappropriate for estimating the economic impacts of the proposed regulations. Therefore, EPA developed a second subcategorization scheme which was used in the Economic Impact Report and this chapter, and was reflective of the three operational modes of coil coating plants:

- Toll Coaters, which coat customer-owned metal (generally do not perform metal fabricating operations),

- Captive Operations, which are part of a proprietary product manufacturing process (e.g., building products, food container packaging),

- Adjustment Operations, which are performed in plants with rolling mills on the plant site (the metal is coated as part of the customers' orders).

In 1976, the coil coating industry consisted of seventy plants which produced a total of 11.4 billion square feet of coil coating. The number of captive operations was slightly larger than the number of adjunct operations (26 versus 23), although the annual production volume of the captives was less than one-half that of the adjunct operations (19 percent versus 46 percent). Toll coaters, on the other hand, account for approximately 30 percent of the plants (21) and a comparable 35 percent of annual production. On an average plant size basis, the square footage of production for adjunct operations was slightly larger than that of the toll coaters and almost three times greater than that of captive operations.

Over 70 percent of the captive plants had annual production volumes of less than 100 million square feet, whereas over 65 percent of the adjunct plants and toll coater plants had annual production volumes greater than 100 million square feet. This disparity in size is explained by the nature of the captive operations, which operate as a part of a total product manufacturing process and thus are limited by the end-product production requirements, as opposed to that of toll coaters and adjunct operations which produce coil coated metals as a primary product.

The coil coating industry which is classified in SIC 3479, has enjoyed a healthy growth rate in the past fifteen years. It experienced a 30 percent growth rate from 1976-79 and is projected to grow through 1985 at the rate of 12 percent. Rapid technological change and product improvement should continue to contribute to industry growth.

Pollutants and Sources

Wastewaters are generated in the cleaning, chemical conversion coating, and finishing processes of the coil coating industry. Strong alkaline, mild alkaline and/or acid is used to remove soil, corrosion, dirt, and oxides that interfere with the conversion coating of the metal strip. Water is used to rinse the strip after it has been cleaned. Conversion coating employs one of the following types of coating materials: phosphate, chromate, complex oxides, or no-rinse. Most of these conversion coating processes are water based and water is used to rinse spent and excess solutions from the strip. In painting, the final process of the coil coating operation, water is used to quench the strip after oven curing the paint. This prevents the development of internal and external stresses.

The exact composition of the wastewater generated will vary depending on the options selected for cleaning and for chemical conversion coating, and the type of base metal coated. The most important pollutants or pollutant parameters as recognized by EPA are:

- toxic pollutants--chromium, zinc, nickel, lead, copper, and cyanide;
- conventional pollutants--suspended solids, oil and grease, and pH; and
- unconventional pollutants--iron, aluminum, phosphorus, and fluoride.

EPA did not find significant quantities of toxic organic pollutants in the wastewater.

Control Technologies

The control technologies that EPA recommended to meet the proposed effluent limitation guidelines for BPT, BAT, PSES, NSPS, and PSNS are as follows:

- BPT--The recommended end-of-pipe treatments as to meet BPT are: reducing hexavalent chromium, skimming oil, adjusting pH, allowing sedimentation to remove the resultant precipitate and other suspended solids, destroying cyanide where used, and dewatering sludge from the settling tank to facilitate landfill disposal.
- BAT and PSES--Control technologies for BAT and PSES build on the technologies established for BPT by adding a mixed-media filter, to reduce process wastewater generation, and by recycling quench water.
- NSPS and PSNS--The recommended technologies for NSPS and PSNS build on the technologies established for BAT and PSES. They further reduce the generation of process wastewater by employing countercurrent rinse modes and no-rinse conversion coating.

Table W5.8.1 illustrates the effectiveness of these technologies by showing the percentage of the various pollutants removed from the raw waste load.

Costing Methodology

The costs for compliance were based on information from the 1981 Development Document and 1980 Economic Impact Report (Ref. 3 and 4) concerning the production process, the number, size, and discharge status of the plants, and the recommended treatment technologies. As mentioned earlier, these cost estimates were based on information concerning the costs of control for toll coaters, captive operations, and adjunct operations.

The total costs of compliance were estimated for each level of treatment for each of the three plant types. Compliance costs for BPT, BAT, and PSES were projected exogenously, while compliance costs for NSPS and PSNS were projected by using cost estimation equations relating costs to production. These equations were based on model plant data presented in the Development Document (Ref. 3).

Technologies costed for BAT and PSES do not reflect the change EPA made in its proposal. EPA modified the subcategory "BAT 2/Pre 3" (as presented in the 1981 Development Document (Ref. 3)) to include countercurrent rinse and no-rinse conversion. EPA estimated in the Federal Register that this modification could reduce the total BPT and BAT investment by 20-25 percent.

The underlying assumptions for this analysis are that replacement capital costs are 90 percent of the original capital investment, O&M costs for the replacement equipment are the same as those for the original equipment, and equipment is replaced after 15 years.

Table W5.8.1 Percent of pollutant removed [1]

Parameter	BPT	NSPS and PSNS
Toxic Pollutants		
Chromium	98.7	99.9
Zinc	96.9	99.4
Nickel	0	75.2
Lead	84.5	94.3
Copper	0	0
Cyanide	79.0	93.9
Conventional Pollutants		
Suspended solids	91.2	99.2
Oil and grease	93.1	97.5
Unconventional Pollutants		
Iron	89.3	96.6
Aluminum	99.8	99.9
Phosphorus	80.2	95.0

[1] These values were calculated using Table X-11 in the Development Document (Ref. 3).

Note: The percentage of pollutants removed under the BAT and PSES treatment levels would be approximately the same as those found under the NSPS and PSNS treatment levels.

The costs of compliance for the coil coating industry are presented in Table W5.8.2. These costs are based on a 1976 survey data of 58 plants in the coil coating industry. They have been extrapolated to the then existing industry total of 70 plants, to plants that have begun operations since 1976, and to expected new plants.

Table W5.8.2. Coil coating

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

	BASE	1978	1983	1988
CAPACITY: IN: SQ. FT./DAY	.0	.0	.0	.0
CAPITAL IN PLACE (KIP):	.0			

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.38	0.0	11.11	25.33	32.71
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.46	0.0	2.49	10.58	35.49
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.17	0.0	3.78	14.60	44.63
ANNUAL CAPITAL + O+M	3.63	0.0	6.27	25.17	80.12
USER CHARGES	0.0	0.0	0.0	0.0	0.0
ALL ANNUAL COSTS	3.63	0.0	6.27	25.17	80.12

Chapter W5.9 Porcelain Enameling

Regulations

The regulatory bases for this chapter are the regulations, as promulgated by EPA on November 24, 1982, that limit the effluent discharges to waters of the United States and introductions of pollutants into publicly owned treatment works (POTWS) from facilities engaged in porcelain enameling. The purpose of the regulations is to specify effluent limitations for best practicable technology (BPT), best available technology (BAT), new source performance standards (NSPS) for direct dischargers and to establish pretreatment standards for indirect dischargers.

The regulations specify the effluent limitations guidelines, performance standards and pretreatment standards for each of the material basis subcategories defined as: (1) steel, (2) cast iron, (3) aluminum, and (4) copper.

Industry Characteristics

Porcelain enameling is a metal finishing process that consists of the application of a glass coating (frit) to steel, cast iron, aluminum, strip steel or copper. The purpose of the coating is to improve the metals' resistance to chemical abrasion and corrosion, and to improve thermal stability, electrical insulation and appearance. The major end uses for porcelain enameling products are the major home appliances (which account for approximately 80 percent of porcelain enamel usage); sanitary ware (which accounts for approximately 10 percent of total usage); and other products such as cookware, architectural panels, and barbecues.

EPA chose the base metal treated as the basis to subcategorize the industry in the technical analysis and regulations, since the pollutants generated in the surface preparation of the metal vary by the type of metal enameled. While this scheme is appropriate from a technical standpoint, the economic and financial impacts of the regulations vary with the type of product enameled, because product market strength, pricing latitude and the ability of manufacturers to substitute alternate materials for porcelain enameling vary by end product. Consequently, in the Economic Impact Report the base metal subcategories were subdivided into the major end product groups. The major end product groups and the number of plants represented by each group are as follows:
(1) ranges--27, (2) home laundry--9, (3) dishwashers--4, (4) hot water heaters--10, (5) sanitary ware--9, (6) cookware--11, (7) architectural panels--11, (8) job shops--23, and (9) miscellaneous (refrigerators, barbecues, etc.)--12.

Company organization within the industry can be defined by two basic types--captive operations which are located within an integrated manufacturing facility and independent job shops. Job shops are plants that perform porcelain enameling on a contract basis and produce a wide range of items. These shops represent approximately 20 percent of the plants but only about 5-8 percent of the production in the industry. The job shops were defined as a separate end product group because they could not be classified in any other end product group.

Of the 116 porcelain enamel plants identified by EPA, sufficient data to conduct economic impact analyses were available from 106 plants. Consequently, the economic impact analyses were conducted on these 106 sample plants and projected for the 116 known plants in the industry.

In 1976, the annual production rates of the 108 plants ranged from 25,000 square feet (of exposed surface area enameled) for a small job shop to 62,190,000 square feet (of exposed surface area) for an integrated appliance manufacturer. All total, the industry enameled 775,000,000 square feet of exposed metal surface area.

Growth in the porcelain enamel industry is highly dependent on trends in porcelain enamel usage and the demand for porcelain enameled end products. The future of porcelain enamel usage depends on whether the substitutions that took place in the last ten to twenty years substantially represent all of the technically feasible and economically viable substitutes. Current trends indicate a continued, though decelerated, decline in the usage of porcelain enamel finishes. On the other hand, porcelain enameled major home appliance demand is highly correlated with new housing starts. Consequently, utilization in the industry will always be cyclical, and industry growth will depend on the long-term trends in the general economy. Over the 1982 to 1987 period, growth of household appliances that contain porcelain enamel is expected to range from 3 to 7 percent annually. This compares to 4.2 percent from total durable manufactures.

The plants in the porcelain enamel industry are classified in the SIC Codes 3431 (enameled iron and metal sanitary ware), 3469 (porcelain enameled products except plumbing supplies), 3631 (household cooking equipment), 3632 (household refrigerators and home and farm freezers), 3633 (household laundry equipment), and 3639 (household appliances, not elsewhere classified). Included among these areas are the large appliance, cookware, architectural panel, and plumbingware industries.

Pollutants and Sources

Wastewaters are generated in the surface preparation and coating processes of the porcelain enameling industry. In the surface preparation process, water-based alkaline cleaners are used to remove oil and dirt. Acid pickling solutions are used to remove corrosion, oxides, and to etch the base metal to be coated, and water is used to rinse spent and excess solutions from the prepared surfaces.

The coating process includes the ball milling of the frit and the enamel application. Water is used in the ball milling operation for flushing the mills between mixing batches and for cooling the mills during operation. The enamel application operation may employ water as a curtain device for entrapping waste coating materials from over spray.

The exact composition of the wastewater generated will vary depending on the process options selected for cleaning and the type of base metal coated. The most important pollutants or pollutant parameters as recognized by EPA are:

- Toxic metal pollutants--antimony, arsenic, cadmium, chromium, copper, cyanide, lead, nickel, selenium, and zinc.
- Conventional pollutants--total suspended solids, pH, oil and grease.
- Nonconventional pollutants--aluminum and iron.

Toxic organic pollutants were not found in the samples analyzed.

Control Technologies

The control technologies which EPA promulgated to meet effluent limitations guidelines for BPT, BAT, PSES, NSPS, and PSNS are as follows:

- BPT--the control technology promulgated to meet this guideline applies to the steel, cast iron and aluminum subcategories and consists of flow normalization, hexavalent chromium reduction (for facilities which enamel aluminum), oil skimming, pH adjustment, and sedimentation to remove resultant precipitate and other suspended solids.
- BAT and PSES--the technology basis for the final regulation includes flow normalization, reuse of treated wastewater in most coatings water using operations, chromium reduction, oil and grease removal and lime and settle end-of-pipe treatment. BAT and PSES requirements apply to the steel, cast iron and aluminum subcategories.
- NSPS and PSNS-- the recommended control technology to meet these guidelines applies to all four subcategories and is based on multi-stage countercurrent cascade rinsing after each metal preparation operation, reuse of water for most coating operations as is required for BAT, oil and grease removal and lime, settle and filter end-of-pipe treatment technology for all wastewaters.

Costing Methodology

The costs for compliance were developed on the basis of number of plants, size, process, treatment and discharge status as given in the Federal Register, Development Document and the Economic Impact Report.

As stated earlier, the proposal regulations were subcategorized on the basis of the type of metal coated because the chemicals and processes that create the discharged pollutants vary by the metal type. However, most plants in the industry have the flexibility to coat more than one metal type, as such, the regulatory subcategories are inappropriate for estimating costs. Consequently, the cost estimates are based on the major end product categories listed below.

- Category 1 (steel)--ranges, home laundry, dishwashers, hot water heaters, sanitary ware,
- Category 2 (aluminum or steel)--cookware, architectural panels.
- Category 3 (steel, copper, cast iron, aluminum, or strip steel) job shops, miscellaneous.

Compliance costs for BPT, BAT, PSES, NSPS, and PSNS were projected exogenously from the Development Document. The cost of compliance for the porcelain enameling industry are presented in Table 5.9.1.

Table W5.9.1. Porcelain enameling

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.09	0.0	6.77	23.75	17.07
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.89	0.0	1.77	8.90	26.76
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.12	0.0	4.22	20.04	59.05
ANNUAL CAPITAL + O+M	3.01	0.0	5.99	28.94	85.82
ALL ANNUAL COSTS	3.01	0.0	5.99	28.94	85.82

Chapter W6. Mineral-Based Industries

For the purpose of this report, Mineral-Based Manufacturing Industries are defined as those establishments primarily engaged in the gathering or physical processing of minerals into a form suitable for use by the ultimate consumer. These include:

- Mineral Mining and Processing
- Glass Manufacturing Industry
- Insulation Fiberglass
- Asbestos Manufacturing
- Cement Industry
- Paving and Roofing Materials

Costs for the reduction of water pollution for these industries are summarized in Table W6.

TABLE W 6. MINERAL-BASED
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 6. 1	MINERAL MINING	1.20	11.70	1.65	5.43	13.43
W 6. 2	GLASS MFG.	3.49	14.73	17.40	22.76	19.37
W 6. 3	INSULATION FIBERGLASS	2.35	16.07	6.53	14.75	37.81
W 6. 4	ASBESTOS	0.87	2.55	2.60	4.03	4.81
W 6. 5	CEMENT MFG.	4.26	37.57	12.17	23.12	63.39
W 6. 6	PAVING & ROOFING	1.84	7.28	4.87	9.35	12.66
	TOTAL INVESTMENT	14.00	89.90	45.21	79.44	151.47

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 6. 1	MINERAL MINING	2.14	3.55	6.08	13.57	29.83
W 6. 2	GLASS MFG.	12.07	10.79	33.59	72.85	136.22
W 6. 3	INSULATION FIBERGLASS	6.82	14.17	18.38	43.66	110.75
W 6. 4	ASBESTOS	2.18	3.43	5.49	13.58	31.19
W 6. 5	CEMENT MFG.	12.31	29.47	34.04	76.69	170.83
W 6. 6	PAVING & ROOFING	11.00	20.60	30.03	68.78	144.97
	TOTAL ANNUAL COSTS	46.53	82.01	127.61	289.13	623.79

Chapter W6.1 Mineral Mining and Processing

Regulations

The only regulations that have been promulgated for this industry are BPT for industrial sand and BPT and NSPS for phosphate rock. The costs shown here are based on these two subcategories of this industry.

Industry Characteristics

The mineral mining and processing industry is concerned with the mining, separation, cleaning, and beneficiation of the following minerals:

- dimension stone
- crushed stone
- construction sand and gravel
- industrial sand
- gypsum
- asphaltic minerals
- asbestos & wollastonite
- lightweight aggregates
- mica
- barite
- fluorspar
- borates
- salines
- tripoli
- garnet
- phosphate rock
- talc
- kaolin
- feldspar
- potash
- trona
- sodium sulfate
- mineral pigments
- lithium
- bentonite
- diatomite
- Frasch sulfur
- graphite
- jade
- magnesite
- novaculite
- shale and common clay
- aplite
- attapulgite and montmorillonite
- rock salt
- kyanite
- fire clay
- ball clay

The production of minerals in the U.S. is closely associated with the rise and fall of the U.S. Gross National Product. Many subsectors have a small production rate in the U.S. due to competition with higher grade or cheaper foreign minerals, small demand for selected U.S. minerals, or alternative supplies of minerals, e.g., sulfur, which is a by-product of many chemical and pollution control processes. Production of minerals from year to year is a dynamic phenomenon for the separate sectors, showing great growth and recession. The following discussion includes only the industrial sand and phosphate rock subcategories, since no final regulations exist for the other groups.

Industrial Sand. Industrial sands are deposits that have been worked by natural processes into segregated mineral fractions. Such deposits are utilized for their contained quartz (S_iO_2). The deposits are found in a broad range of locations and formations, some as loose and visible as dune sand, others as dense and obscure as the hardest of rocks buried under a variety of surface materials, and in literally all intermediate types of formations. They may be found as low-lying water-bearing sands, as hard-faced bluffs and cliffs, as out-cropped escarpments on a level plain or as a massive ridge or mountain face. It is believed that there is only one operating underground mine.

Phosphate Rock. "Phosphate rock" is a commercial term for a rock that contains one or more phosphate minerals--usually calcium phosphate--of sufficient grade and suitable composition to permit its use, either directly or after concentration, in manufacturing commercial products. The term "phosphate rock" includes phosphatized limestones, sandstones, shales, and igneous rocks.

Present western phosphate mining operations are open pit. However, most of the western reserve is deep, requiring selective underground mining, which will continue to be economically viable only if future phosphate rock prices are high. The western region accounts for only 13 percent of domestic phosphate rock production. Due to local mineral characteristics and corresponding process practices, and because of the favorable rainfall/evaporation balance existing for the western facilities, all six producers in this region will soon be operating with no discharge of wastewaters. Therefore, they will experience no incremental costs upon implementation of the proposed effluent guidelines. Producers in the eastern district must already comply with effluent guidelines close to those proposed. Only four facilities are known to be exceeding the proposed limits; all four are in Central Florida. As far as is known, the facilities in North Carolina and Tennessee (each state accounting for only about 5 percent of national production) will not be affected.

Pollutants and Control Technology

Effluents from the mineral mining and processing industry are generally high in suspended solids and mineral content, depending on the solubility of the specific ores. Typically, treatment technology consists of settling ponds to remove suspended solids and sometimes lime precipitation to remove metals and adjust pH. For difficult suspended solids, flocculant addition and thickeners can be used. Where settling ponds are not sufficient, filters can be used to augment treatment. Effluents are generally from two distinct sources, mine dewatering and beneficiation operations (milling, washing, and separation of minerals). The effluent from beneficiation operations is usually higher in suspended solids than that from mining operations.

Costing Methodology

Table W6.1.1 is a summary of BPT compliance costs for the above categories of the mineral mining and processing industry. The costs were developed using model plant treatment technology sufficient to meet the effluent guidelines.

Table W6.1.1. Mineral mining and processing

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .420E+06

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.20	11.70	1.65	5.43	13.43
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.75	2.97	4.95	11.20	25.32
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.39	0.59	1.13	2.37	4.51
ANNUAL CAPITAL + O+M	2.14	3.55	6.08	13.57	29.83
ALL ANNUAL COSTS	2.14	3.55	6.08	13.57	29.83

Chapter W6.2 Glass Manufacturing Industry

Regulations

The costs presented in this chapter are reflective of EPA's promulgated regulations that establish effluent limitations guidelines for best practicable technology (BPT) and best available technology (BAT), performance standards for new sources (NSPS) and pretreatment standards for new and existing sources (PSNS, PSES) for firms in the glass manufacturing point source category. The promulgated regulations were specified for twelve subcategories of the industry in two phases. The first phase of regulations addressed firms engaged in the manufacturing of flat glass and were published in the Federal Register on February 14, 1974 (Ref. 7). The second phase addressed those firms engaged in the manufacturing of pressed and blown glass, and were published in the Federal Register on January 16, 1975 (Ref. 8). Subsequent amendments to the regulations were published in the Federal Register on February 11, 1975 (Ref. 9) and August 29, 1979 (Ref. 10).

Since the subcategories of the industry were divided into two groups in the regulations (Ref. 7,8) and contractor's cost reports (Ref. 3, 4, 5, 6), the remaining sections of this chapter are presented separately for each group--(1) flat glass, and (2) pressed and blown glass.

Industry Characteristics (Flat Glass)

The flat glass industry may be divided into six major subcategories based on the process employed. These are:

- Sheet Glass Manufacturing
- Rolled Glass Manufacturing
- Plate (or primary) Glass Manufacturing
- Float Glass Manufacturing
- Automotive Glass Tempering
- Automotive Glass Laminating

The sheet and rolled glass manufacturing industries do not discharge wastewater, therefore, they are not considered in this analysis.

Plate glass is formed by a rolling process; then it is ground and polished on both sides. Float glass is formed by cooling a layer of molten glass on a bed of molten tin. Tempered glass is flat glass that has been toughened by being heated above its strain point and then quickly cooled. Laminated glass consists of plates of glass bonded to a sheet of plastic to provide protection against shattering.

The major division within the industry is between primary and automotive glass manufacturers and the processes they use. Plants that produce plate and float glass are classified in SIC 3211 as establishments primarily engaged in manufacturing flat glass and flat glass products from materials taken from the earth in the form of sand (i.e., primary glass manufacturers). Plants that fabricate glass products (e.g., automotive window glass) from purchased glass are classified in SIC 3231 (Ref. 3, pp. 15, 18).

The flat glass industry is a cyclical industry, heavily affected by economic conditions in the construction and automotive industries, the two largest users of flat glass. Both of these industries were depressed in 1980 and 1981 but are expected to recover in 1982. Concerns for energy conservation will continue to aid the market for double and triple glazing and for solar products. The rehabilitation and retrofitting of real estate are other expanding markets for flat glass. Consequently, for the five years ending in 1985 flat glass shipments are expected to rise at a real compound growth rate of 4 percent (Ref. 2, p. 21). For the same period, automotive glass shipments are expected to grow at the same rate as automotive production, i.e., 1.5 percent.

Pollutants and Sources (Flat Glass)

In the manufacture of sheet and rolled glass, no process wastewater is produced. Although water is added to raw materials for dust suppression, the water is evaporated in the melting tank.

In plate glass manufacturing, process wastewater is produced in the grinding, polishing and washing operations. Most of the wastewater is contributed by the grinding process. The major waste constituent, resulting from plate glass manufacturing is suspended solids, although dissolved solids, BOD, and COD may also be present in the wastewater. The grinding operation contributes most of the suspended solids.

Some plants in the float subcategory wash the glass prior to packing and this constitutes the only wastewater stream. TSS, oil, COD, and dissolved solids were identified in the wastewater.

In the automotive glass tempering subcategory, wastewater is produced in the seaming, grinding, drilling, quenching, cooling, and washing operations with the washing and drilling operations accounting for 90 percent of the wastewater. Suspended solids are added by the seaming, grinding, and drilling wastewaters; oil by the grinding solution carryover; BOD by oil in the coolant solution carryover; and dissolved solids by water treatment regenerants and boiler blowdown.

Water is used in the automobile glass laminating subcategory for cooling, seeming, and washing. Three or four washes are required when oil autoclaves are used, and initial vinyl, and postlaminated washes are required in all cases. Some plants still employ prelamination washes. Eighty percent of the wastewater is contributed by initial washing, and final washing. Major wastewater constituents are suspended solids, oils, COD, BOD and phosphorus. Suspended solids are contributed to the wastestream by the seeming operation; oil is contributed by the laminating process; COD is contributed by the postlamination wash as a result of the high oil content. Phosphorus results from detergents used in the preassembly and postlamination.

The concentration of pollutants in the wastewater varies by subcategory. EPA estimated that the concentration of suspended solids was as high as 15,000 mg/l in the plate glass subcategory and only 15 mg/l in the float glass subcategory. Oil and COD concentrations were estimated to be 1700 mg/l in the automobile glass lamination subcategory and significantly lower in all other subcategories. Phosphorus was found only in the automobile glass lamination subcategory, although information was not available for the float glass subcategory.

Control Technologies (Flat Glass)

There are no specific pretreatment standards for new sources other than to comply with national pretreatment standards. The pretreatment standards for existing sources in all subcategories except automotive laminating and float glass specify no limitations. Pretreatment standards for the automotive laminating and float glass subcategories have not been promulgated.

Although BPT, BAT, and NSPS effluent limitations for the sheet glass and rolled glass subcategories call for zero discharge, plants in these subcategories have no process wastewater, thus, no technologies are needed to meet these regulations.

For the plate glass subcategory, BPT technology requires partitioning of existing lagoon cells and polyelectrolyte addition. No BAT regulations are currently in force. For NSPS, EPA has promulgated zero discharge limitations, although it does not recommend a specific technology. The Development Document indicates that it is unlikely that any new plants will be built, consequently no costs were assigned for new source plants.

For the float glass subcategory, BPT technology is the elimination of detergents in the float washer to reduce the discharge of phosphorus. BAT regulates only phosphorus and at the same level as BPT, thus, no additional treatment technology is needed. For NSPS, EPA recommended diatomaceous earth filtration and elimination of detergents.

In the automotive glass tempering, BPT technology is coagulation - sedimentation with centrifugation of waste sludge. No BAT regulations are currently in force. For NSPS, EPA recommended diatomaceous earth filtration in addition to BPT technology.

For automotive glass laminating, EPA recommended continuously recycling initial hot water rinse, centrifugation of the recycled hot water rinse to remove oil, and gravity oil separations. BAT regulations are currently in force for phosphorus control, however, no end-of-pipe treatment exists. NSPS standards are diatomaceous earth filtration in addition to BPT.

Costing Methodology (Flat Glass)

Model plants are used to estimate the regulatory costs in the flat glass industry. These model plants for each subcategory were derived in the Development Document (Ref. 3). The Appendix summarizes the sizes of model plants, the costs for each model plant and the resulting equations.

Industry Characteristics (Pressed and Blown Glass)

The effluent limitations guidelines for the pressed and blown glass manufacturing industry cover manufacturers of glass containers for commercial packing, bottling, home canning, and the manufacturers of glass and glassware, which is pressed, blown, or shaped from glass produced in the same establishment.

The industry has been divided into the following subcategories, based upon differences in production processes and wastewater characteristics:

- Glass containers
- Machine-pressed and blown glass
- Glass tubing
- Television picture tube envelopes
- Incandescent lamp envelopes--forming and frosting
- Hand-pressed and blown glass--leaded and hydrofluoric acid finishing, and nonhydrofluoric acid finishing

Four manufacturing steps are common to the entire pressed and blown glass industry: weighing and mixing of raw materials, melting of raw materials, forming of molten glass, and annealing of formed glass products. Further processing (finishing) is required for some products, especially television tube envelopes, incandescent lamp envelopes, and hand-pressed and blown glass.

Sand (silica) is the major ingredient of glass and accounts for about 70 percent of the raw materials batch. Other ingredients may include soda or soda ash (13-16 percent), potash, lime, lead oxide, boric oxide, alumina, magnesia, and iron or other coloring agents. The usual batch also contains between 10 and 50 percent waste glass (cullet).

Melting is done in three types of units: continuous furnaces, clay pots, or day tanks. Methods used to form glass include blowing, pressing, drawing, and casting. After the glass is formed, annealing is required to relieve stresses that might weaken the glass or cause the product to fail. The entire piece of glass is brought to a uniform temperature that is high enough to permit the release of internal stresses and then cooled at a uniform rate to prevent new stresses from developing; finishing steps include abrasive polishing, acid polishing, spraying with frosting solutions, grinding, cutting, acid etching, and glazing (Ref. 4).

The U.S. Bureau of Census, Census of Manufacturers, classifies the manufacturers of glass containers in SIC 3221 and the manufacturers of all other pressed and blown glass products in SIC 3229 (Ref. 6).

The most promising growth prospects for the glass container industry are in the beer and soft drink markets. Competition from other types of containers, however, is expected to keep the annual growth rate in the glass container industry at approximately 1.0 percent per year (Ref. 4, p. 73). Indirect competition from plastics will continue to affect the demand for handmade glassware and glasstubing; however, the adverse affects are expected to be minimal and growth will be at about the same annual rate as the GNP, i.e., 3.2 percent. There is no material competitive with glass for electric light bulbs, as such, demand will grow as electricity demands increase (Ref. 6).

Pollutants and Sources (Pressed and Blown Glass)

Water is used during the manufacture of pressed and blown glass for noncontact cooling, quenching of cullet, contact cooling of metallic forming of cutting devices, batch wetting, abrasive polishing, edge grinding, washing, and assorted other uses.

For the purpose of establishing effluent limitations guidelines, the following pollution parameters were determined significant: fluoride, ammonia, lead, oil, total suspended solids (TSS), and pH. These parameters are not present in the wastewater from every subcategory, and may be more significant in one subcategory than in another. Wastewaters from noncontact cooling and boilers are not considered process wastewaters and are not covered by the guidelines.

In the manufacturing of glass containers, process water is used for cullet quenching, batch wetting, and contact cooling of shears. Water used for cullet quenching accounts for nearly all of the flow. Principal pollutants associated with this subcategory are oil, which is present in the shear spray or is due to leaking lubricants, and TSS, which is present in the wastewater from cullet quenching.

In the Danner tubing subcategory, the major source of process wastewater is from cullet quenching while the principal pollutant discharged is TSS.

In the manufacturing of television picture tube envelopes, process wastewater originates from many sources. TSS originates in the cullet quench water, batch wetting, abrasive polishing and acid polishing discharge streams. Fluoride is contributed to the waste stream by the fume scrubbers and acid polishing rinse waters. Lead is present in both the abrasive polishing and edge grinding streams.

In the incandescent lamp envelope subcategory, major pollutants include oil, TSS, fluoride, and ammonia. Oil is contributed by shear spray drippage and lubrication leaks, while TSS is present in the cullet quench water, contact cooling of shears, and the rinse water of frosted bulbs. Fluoride and ammonia are present only in wastewaters of plants that have frosting operations. The frosting rinse water contains fluoride and ammonia. Ammonia is also present in fume scrubber discharge.

In the production of hand pressed and blown glass, TSS is present in wastewaters of all finishing steps including grinding, polishing, and cutting. Lead is contributed to the waste stream by acid treatment of lead glass. Acid polishing and etching rinse waters contain fluoride.

The concentration of these pollutants in the wastewater varies by subcategory. In the sampling of wastewaters from plants in the pressed blown and glass industry, EPA found that TSS in the raw wastewater was as low as 24 mg/l while the concentration of lead varied from 30 mg/l to 100 mg/l. Oil varied the least from 10 mg/l to 25 mg/l. Ammonia which was found only in the wastewater from frosting operations of incandescent lamp plants was 650 mg/l.

Control Technologies (Pressed and Blown Glass)

BPT--None of the subcategories need additional treatment to meet BPT effluent limitation guidelines although EPA projected that improved housekeeping techniques may be needed for some glass container and glass (Danner) tubing plants. However, most plants could meet the guidelines through normal maintenance and cleanup operations.

For plants in the television picture tube envelope and incandescent lamp envelope subcategories, EPA also recommended no further treatment. At the time of promulgation, it was common practice for plants in both subcategories to employ lime addition, precipitation, coagulation, sedimentation and pH adjustment. Incandescent lamp envelope plants also used oil skimmers. Some plants may need to employ stricter housekeeping to meet the BPT guidelines.

For plants in the hand pressed and blown glass manufacturing subcategory, EPA did not specify any BPT limitations due to anticipated serious economic impacts.

BAT--for two subcategories (glass containers and glass tubing), EPA has revoked BAT standards and no cost estimates were made. For the remaining subcategories, EPA recommended technologies to meet BAT standards are:

- TV tube envelopes: sand filtration of lime precipitation
- Incandescent lamp envelopes: sand filtration, stream stripping for removal of ammonia, recarbonation
- Hand pressed and blown glass: batch lime precipitation, sedimentation, recarbonation, sand filtration. (Plants in this subcategory with a discharge of less than 50 gallons per day of process wastewater are exempted from meeting BAT guidelines.)

NSPS--For TV tube envelopes, incandescent lamp envelopes and hand-pressed and blown glass, NSPS is identical to BAT standards and the same technologies are assumed. For glass containers and glass (Danner) tubing, the following technologies were costed:

1. Glass containers: stream segregation, recycling of cullet quench through a gravity oil separator, treatment of blowdown by dissolved air flotation
2. Glass (Danner) tubing: recirculation of cullet quench through a cooling tower with blowdown treated by a diatomaceous earth filter

PSNS--For PSNS regulations, EPA specified no limitations for the glass (Danner) tubing subcategory. For the glass container subcategory, EPA specified standards for oil (mineral) which were identical to the BPT standards. Since the BPT standards did not require further treatment, it was assumed that no further treatment would be required for new source pretreaters. Thus, for glass (Danner) tubing and glass containers, costs were assumed to be zero. For all other subcategories, PSNS limitations are identical to BAT limitations for oil (mineral) and fluoride while no limitations were specified for other pollutants. Because limitations for oil (mineral) and fluoride were identical to BAT, BAT technologies were assumed.

PSES--EPA has not promulgated regulations for existing pretreaters.

Costing Methodology (Pressed and Blown Glass)

For each of the subcategories, capital and O&M costs were presented for a typical model plant in the Development Document (Ref. 4). The cost estimating equations for each subcategory are presented in the Appendix. The costs for each of the model plants as presented in the Development Document (Ref. 4) are also included.

These costs and model plants are used in this study to estimate the total regulatory cost, shown in Table W6.2.1.

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

Table W6.2.1. Glass manufacturing industry

	BASE	1978	1983	1988	
CAPACITY: IN: MT/DAY	.233E+06	.253E+06	.284E+06	.306E+06	
CAPITAL IN PLACE (KIP):	.718E+06				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	1.32	0.0	0.0	0.0
BAT	2.88	0.0	8.64	11.53	5.76
NEW PLANTS (NSPS)	0.60	13.41	8.76	11.23	9.33
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	4.27
TOTAL	3.49	14.73	17.40	22.76	19.37
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.15	0.46	0.46	0.93	1.55
BAT	1.02	0.0	2.03	6.09	13.20
NEW PLANTS (NSPS)	2.60	3.03	7.64	15.99	30.83
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	1.01
TOTAL	3.77	3.49	10.13	23.01	46.59
O + M					
EXISTING PLANTS					
BPT	0.21	0.60	0.65	1.29	2.20
BAT	1.28	0.0	2.53	7.50	15.59
NEW PLANTS (NSPS)	6.80	6.70	20.29	41.05	71.22
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.61
TOTAL	8.29	7.29	23.46	49.84	89.63
ANNUAL CAPITAL + O+M	12.07	10.79	33.59	72.85	136.22
USER CHARGES	3.81	9.43	11.06	22.27	36.85
ALL ANNUAL COSTS	15.88	20.21	44.65	95.13	173.07

Chapter W6.3 Insulation Fiberglass

Regulations

The costs of compliance shown in this chapter are based on documentation associated with the regulations as originally promulgated. BAT regulations for this industry are currently under review. The chapter has not been updated since costs for compliance are subject to change if the BAT regulations are modified.

Industry Characteristics

The insulation fiberglass industry has no subcategories. The raw materials for fiberglass production are 55-73 percent silica and 45-27 percent fluxing oxides (e.g., limestone and borates) to manufacture the fiberglass filaments, and a phenolic resin to bind the filaments together. Four basic types of glass are used: low-alkali lime alumina borosilicate, soda-lime borosilicate, lime-free borosilicate, and soda-lime.

The basic process for fiberglass manufacture is as follows. The raw materials batch is melted to form a homogeneous glass stream. There are two ways that the melting process can be done: direct melting or marble process. The molten glass stream is then fiberized to form a random mat of fibers which are bonded together with a thermosetting phenolic binder or glue. The glass is fiberized by either flame attenuation or rotary spinning. The trend in the industry is toward more direct melting and rotary spinning.

The primary domestic uses for insulation fiberglass are: insulating material, noise insulation products, air filters, and bulk wool products.

There are 19 insulation fiberglass plants owned by three major companies. Ten of these plants currently have BPT equipment in place. The typical plant produces 123 thousand metric tons (136 thousand short tons) per year, and all plants have a wastewater discharge.

Pollutants and Sources

The main sources contributing to total waste load are summarized in Table W6.3.1.

Control Technology and Costs

Because of the large volume of process waters and because the chain wash water often contains phenol, formaldehyde, and other contaminants, total recycling of wastewaters is the most economical treatment alternative for the insulation fiberglass industry. Sample recycling systems consist of coarse filtration, followed by either fine filtration or flocculation and settling.

Effluent control costs are summarized in Table W6.3.2.

Table W6.3.1. Insulation fiberglass industry pollutant sources waste streams

Pollutants	Air Scrubbing	Boiler Blow-down	Caustic Blow-down	Chain Spray	Cullet Cooling	Fresh Water Treat-ment	Hood Spray	Noncon-tact Cooling Water
Phenols	X	-	-	X	-	-	X	-
BOD_5	X	-	-	X	-	-	X	-
COD	X	-	-	X	-	-	X	-
TDS	X	X	X	X	X	X	X	X
TSS	X	X	X	X	X	X	X	-
Oil and Grease	-	-	-	X	-	-	X	-
Ammonia	-	-	-	X	-	-	X	-
pH	-	-	X	X	-	X	X	-
Color	X	-	-	X	-	-	X	-
Turbidity	X	X	X	X	-	X	X	-
Temperature (Wasted heat)	X	X	X	-	X	X	-	X
Specific conductance	X	X	X	X	-	X	X	-

Source: EPA Development Document, January, 1979

Table W6.3.2. Insulation fiberglass

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .713E+07

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	8.04	0.0	0.0	2.17
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	2.35	8.03	6.53	14.75	35.64
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.35	16.07	6.53	14.75	37.81
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	1.06	3.17	3.17	6.34	10.53
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	1.91	3.00	4.84	12.69	37.59
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.97	6.18	8.01	19.03	48.12
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	1.37	4.11	4.11	8.21	13.68
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	2.48	3.89	6.26	16.42	48.95
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	3.85	7.99	10.37	24.63	62.63
ANNUAL CAPITAL + O+M	6.82	14.17	18.38	43.67	110.75
ALL ANNUAL COSTS	6.82	14.17	18.38	43.67	110.75

Chapter W6.4 Asbestos Manufacturing

Regulations

Regulations for all eleven industry subcategories have been promulgated for BPT, BAT (old), NSPS and pretreatment for new sources. BAT limitations have been revised. In 1981, the BCT requirements, originally added in 1979, were remanded. Therefore this chapter does not include any estimate of BCT costs. All other costs are based on the development documents referenced in the Appendix.

Industry Characteristics

As of 1978, the main asbestos consumers were the manufacturers of cement pipe (35%), floor tiles (20%), friction products (12%), roofing products (10%) and cement sheet (6%). Asbestos-cement pipe is used mainly for sewer lines. Asbestos sheet is used for laboratory table tops and other structural uses. Asbestos paper and millboard have a wide variety of uses, but are particularly used for applications where direct contact with high temperatures occurs. Asbestos roofing and floor tiles are fabricated products that take advantage of the unique qualities of asbestos. The primary reasons for the use of asbestos fiber in textile products are its durability and resistance to heat, fire, and acid. Asbestos is the only mineral that can be manufactured into textiles using looms and other equipment. Textile products are primarily used for friction materials, industrial packing, and electrical and thermal insulation.

Asbestos cement pipe, cement sheet, paper, and millboard are manufactured with similar methods. The asbestos fibers and other raw materials are slurried with water and then formed into sheets. Settling tanks (save-alls) are used in all processes. In roofing manufacture, asbestos paper is impregnated with asphalt or coal tar. In floor tile manufacture, asbestos is added to the tiles for its special structural and dimension-holding qualities. Textile manufacture involves the coating of asbestos yarn or cloth. The material is drawn through one or more dip tanks and the coating material is spread by rollers, brushes, or doctor blades. The coated textile product then passes through a drying oven where the solvent is evaporated.

Shipments of asbestos (mostly chrysotile) in 1978 from mines in the United States increased minimally from those in 1977. Imports were 4 percent higher than in 1977, but U.S. demand continued to lag well below the peak year of 1973. The predicted annual growth rate of 2.0 percent for U.S. asbestos consumption is an average of three predicted growth rates presented in Table 2 of the Appendix. The apparent consumption for 1974 was about 767,000 MT and for 1978 about 619,000 MT. It is expected to increase to about 800,000 MT by 1985 and to about 940,000 MT by the year 2000.

Pollutants and Sources

Asbestos manufacturing wastes include total suspended solids (including asbestos fibers), BOD_5, COD, pH, alkalinity, high temperature, total dissolved solids, nitrogen, phosphorus, toxic substances, oil and grease, organic matter, nutrients, color and turbidity. The basic parameters used to define asbestos plant effluents are COD, TSS, and pH.

The major source of wastewater in the industry is the machinery that converts the asbestos slurry into the formed wet product. Water is used as an ingredient, as a carrying medium, as a coolant, and for such auxiliary uses as pump seals, wet saws, and pressure-testing pipes. Textile plants use little water in their operations. The addition of moisture during weaving or braiding and during coating generates small amounts of wastewater. In all subcategories, water is removed to the settling tank (save-all system).

Control Technology

The basic treatment technology used by the asbestos industry to meet BPT guidelines is sedimentation. Neutralization, coagulation, and skimming are also used in combination with settling tanks to achieve BPT levels. No discharge limitations, which apply to most BAT and some NSPS and BPT guidelines, can be met with a complete recycle process.

Costing Methodology

The costs of compliance were estimated using an industry model for each of the regulated subcategories and a single model for the Phase II portion of the industry. Most of the information for the cost estimate was taken from Development Documents, Economic Analysis Documents, or associated prior studies of economic impact by EPA contractors. The estimated costs of compliance are listed in Table W6.4.1.

Table W6.4.1. Asbestos manufacturing

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.545E+07 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	1.52	0.0	0.0	0.37
BAT	0.62	0.0	1.85	2.47	1.24
NEW PLANTS (NSPS)	0.26	1.03	0.74	1.56	3.20
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.87	2.55	2.60	4.03	4.81
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.20	0.65	0.60	1.20	1.99
BAT	0.24	0.0	0.49	1.46	3.17
NEW PLANTS (NSPS)	0.23	0.38	0.60	1.51	4.01
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.68	1.03	1.69	4.18	9.17
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.37	1.21	1.11	2.21	3.93
BAT	0.38	0.0	0.77	2.31	5.00
NEW PLANTS (NSPS)	0.75	1.19	1.93	4.88	13.09
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.51	2.40	3.81	9.40	22.02
ANNUAL CAPITAL + O+M	2.18	3.43	5.49	13.58	31.19
ALL ANNUAL COSTS	2.18	3.43	5.49	13.58	31.19

Chapter W6.5 Cement Industry

Regulations

BAT regulations for the industry covered in this chapter are currently under review by EPA. It is anticipated that the review may result in some change in the regulations, with subsequent effects on the estimated cost of compliance. Because of possible changes in the BAT regulations following the review, this chapter has not been updated. The costs shown here are based on documentation associated with the regulations as originally promulgated, and the costs for compliance with BAT are subject to change if the BAT regulations are modified.

Industry Characteristics

The cement industry is divided into two basic manufacturing processes: wet and dry.

A facility using the wet process grinds up the raw materials with water and feeds them into the kiln as a slurry.

A facility using the dry process dries the raw materials, grinds and then feeds them into the kiln in a dry state.

In each of these processes, there are three major steps: grinding and blending, clinker production, and finish grinding. Clinker is a material about the size of a large marble which has been through the kiln but has not been fine-ground into finished cement.

The raw materials for cement production include lime (calcium oxide), silica, alumina, iron, and gypsum. Lime, the largest single ingredient, comes from cement rock, oyster shell marl, or chalk.

Prices have increased due to higher production costs and pollution abatement costs. Fuel cost increases are also expected to affect prices.

Pollutants and Sources

In terms of the generation of water pollutants, the cement industry is divided into three subcategories:

- Leaching plants. The contaminated water is from leaching systems installed to reprocess collected kiln dust and from the wet scrubbers that control stack emission.
- Nonleaching plants. The contamination of water is not a direct function of the water usage.

- Pile materials. Runoff from piles of kiln dust, clinker, coal or other materials that are subject to rainfall.

The main sources contributing to the total waste load come from the following: in-plant leakage, noncontact cooling water, process water, kiln dust pile runoff water, housekeeping water, and effluent from wet scrubbers.

In order to define waste characteristics, the following basic parameters were used to develop guidelines for meeting BPT and BAT: pH, total dissolved solids, total suspended solids, alkalinity, potassium, sulfate, and temperature (waste heat).

BPT for plants in the nonleaching subcategory has been defined as no discharge of pollutants from manufacturing except for thermal discharge for which an increase of 3°C (5.5°F) is permitted.

For plants in the leaching subcategory, BPT is the same as for the nonleaching subcategory except for the dust-contact streams where a reduction of pH to 9.0 and of suspended solids to 0.4 kg/metric ton of dust leached is required. For plants subject to the provisions of the Materials Storage Piles Runoff Subcategory, either the runoff should be contained to prevent discharge or the runoff should be treated to neutralize and reduce suspended solids.

BAT for both leaching and nonleaching plants is defined as zero discharge of pollutants. For plants subject to the provisions of the Materials Storage Piles Runoff Subcategory, the definition of BPT is applied to BAT.

NSPS is the same as BPT except that no discharge is permitted for plants with materials storage pile runoff.

Control Technology and Costs

The main control and treatment methods for the cement industry involve recycle and reuse of wastewater. The devices employed include cooling towers or ponds, settling ponds, containment ponds, and clarifiers.

For leaching plants, additional controls are needed for adequate control of alkalinity, suspended solids, and dissolved solids. Alkalinity is controlled by neutralization, or carbonation; suspended solids by clarification, sometimes with the addition of flocculating agents. Although none of the leaching plants currently uses a treatment method to control dissolved solids, several processes that might be employed include precipitation, ion exchange, reverse osmosis, electrodialysis, and combinations of these followed by total evaporation.

In-plant control methods include good maintenance and operating procedures to minimize solid spillage and to return dry dust to the process. Solids introduced into storm water runoff can be minimized by paving areas for vehicular traffic, providing good ground cover in other pen areas, removing accumulations of dust from roofs and buildings, and by building ditches and dikes to control runoff from materials storage piles.

Control costs are summarized in Table W6.5.1.

Table W6.5.1. Cement industry

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.232E+08 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	32.71	0.0	0.0	14.14
BAT	1.39	0.0	3.94	5.36	2.81
NEW PLANTS (NSPS)	2.88	4.85	8.23	17.76	46.43
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.26	37.57	12.17	23.12	63.39
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	4.30	14.16	12.90	25.81	43.11
BAT	0.52	0.0	1.02	3.13	6.86
NEW PLANTS (NSPS)	1.72	0.95	4.04	11.67	39.74
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	6.54	15.10	17.96	40.61	89.71
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	5.31	14.36	15.18	32.23	58.32
BAT	0.47	0.0	0.90	2.92	6.65
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.92	16.15
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	5.77	14.36	16.08	36.08	81.12
ANNUAL CAPITAL + O+M	12.31	29.47	34.04	76.69	170.83
ALL ANNUAL COSTS	12.31	29.47	34.04	76.69	170.83

Chapter W6.6 Paving and Roofing Materials

Regulations

The costs included in this chapter are for BPT, BAT, and NSPS requirements. This industry has been exempted from additional federal guidelines under paragraph 8 of the 1976 settlement agreement with NRDC. The regulations for this industry are cited in 40 CFR 443.

Industry Characteristics, Pollutants and Control Technology

Establishments covered under these guidelines include: (1) Asphalt emulsion plants (SIC 2951); (2) Asphalt concrete plants (SIC 2951 and 1611); (3) Asphalt roofing plants (SIC 2952) and (4) Linoleum and asphalt felt flooring (SIC 3996).

Asphalt Emulsion Plants. About 50 plants produce asphalt emulsions. The chief source of pollutants is water from the wet collection of waste fumes and the runoff of precipitation.

The costs of meeting the regulations for a typical plant of 5,500 metric tons (6,000 short tons) per day have been developed by EPA for the BPT, BAT, and NSPS case, and are applied to the 7 plants not in compliance in 1974, the year the regulations were proposed. Eighteen plants at that time were meeting the BPT standards, of which 8 met BAT standards. (This was industry practice, not anticipation of the regulations.) Twenty-five plants discharge to municipal sewers.

Industry size was static from 1971-75 but was expected to grow at 4 percent per year through 1980 and at 1.65 percent per year from 1981 to 85. These estimates were based on expected highway construction and repair.

Asphalt Paving Plants. Approximately 3,180 plants use wet scrubbers to remove particulates from the air, thereby creating a potential water pollution problem. (The rest of the industry group uses fabric filters.) The BPT, BAT, and NSPS requirements are the same--no discharge of pollutants. This can be readily achieved by the use of an earthen settling basin or lagoon, or by use of a mechanical sedimentation tank. Costs derived in the EPA Development Document have been used. No pretreatment costs have been calculated, since, according to a recent survey, only one plant discharges to a municipal system. Forty percent of new plants or expansions occurring after 1974 are expected to use wet scrubbing; the balance will use dry air pollution control methods and thus will not incur water pollution control costs. The balance are estimated to have changed to fabric filters to abate air pollution and avoid the costs of upgrading their water clean-up system. Forty percent of future plants are expected to use wet systems.

Asphalt Roofing. In 1974, 225 plants produced a variety of asphalt and tar roofing materials including shingles, felts, siding materials, and coatings. The chief pollution problem arises from oil and particulate in the cooling water that is used directly on the material. In addition, most plants have a tower for blowing asphalt. The ground adjacent to this unit is usually saturated with asphalt so that precipitation runoff becomes contaminated with oils.

The costs for meeting BPT, BAT, and NSPS for a plant of 450 metric tons per day (500 short tons per day) have been developed by EPA and have been applied to the 21 plants not conforming to BPT regulations and the additional 21 plants meeting BPT but not BAT standards.

Growth of the industry was assumed to be 3.5 percent per year.

Linoleum and Asphalt Felt Flooring. This industry segment of the tar and asphalt products industry is quite small (3 plants estimated) and the costs for conforming to the regulations are small ($6,100 capital investment and $2,570 O&M for a typical plant). For these reasons, the costs have not been tabulated or included.

Control Costs

The total costs for asphalt emulsion plants, asphalt paving plants and asphalt roofing plants are shown in Table W6.6.1.

Table W6.6.1. Paving and roofing materials

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.215E+08				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	2.87	0.0	0.0	0.89
BAT	1.14	0.0	2.27	4.54	3.41
NEW PLANTS (NSPS)	0.70	4.41	2.60	4.81	8.36
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.84	7.28	4.87	9.35	12.66
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.38	1.09	1.13	2.26	3.76
BAT	0.30	0.0	0.45	2.09	5.52
NEW PLANTS (NSPS)	0.92	1.42	2.49	5.83	13.60
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1.60	2.51	4.07	10.18	22.88
O + M					
EXISTING PLANTS					
BPT	2.48	7.67	7.43	14.87	24.95
BAT	0.46	0.0	0.69	3.20	8.46
NEW PLANTS (NSPS)	6.47	10.42	17.84	40.52	88.68
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	9.41	18.09	25.96	58.59	122.08
ANNUAL CAPITAL + O+M	11.00	20.60	30.03	68.78	144.97
ALL ANNUAL COSTS	11.00	20.60	30.03	68.78	144.97

Chapter W7. Forest Products Industries

For the purpose of this report, the Forest Products Industries are defined as those establishments engaged in gathering and processing forest products and in the manufacture of consumer goods from these materials. These are the:

- Timber Products Processing
- Timber Products Process: Wood Furniture and Fixture Manufacturing
- Gum and Wood Chemicals
- Pulp, Paper, and Paperboard

Costs for the reduction of water pollution for these industrial sectors are summarized in Table W7. These costs and other data are repeated below in the appropriate sections together with the assumption specific to the industry and other details.

TABLE W 7. FOREST PRODUCTS INDUSTRIES WATER POLLUTION CONTROL COSTS (IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 7. 1	TIMBER PROD.	2.60	264.21	9.89	19.59	24.55
W 7. 2	FURNITURE MFG.	0.0	29.01	0.0	0.0	0.22
W 7. 3	GUM & WOOD CHEMICALS	2.90	43.51	7.11	13.78	42.23
W 7. 4	PULP & PAPER	8.01	3214.10	8.01	36.02	194.41
	TOTAL INVESTMENT	13.50	3550.84	25.00	69.39	261.41

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 7. 1	TIMBER PROD.	56.56	180.29	166.39	340.62	574.75
W 7. 2	FURNITURE MFG.	7.02	26.49	21.06	42.13	70.39
W 7. 3	GUM & WOOD CHEMICALS	9.97	34.13	28.01	61.95	115.87
W 7. 4	PULP & PAPER	810.26	2582.40	2427.31	4868.21	8095.56
	TOTAL ANNUAL COSTS	883.81	2823.31	2642.77	5312.90	8856.57

Chapter W7.1 Timber Product Processing (Nonfurniture)

Regulations

Effluent discharge regulations for the timber product processing (nonfurniture) subcategories are reported in the Federal Register (Vol. 46, No. 16, Monday, January 26, 1981) and summarized in the appendix. The regulations apply to fourteen subcategories including:

A. Barking
B. Veneer
C. Plywood
D. Dry Process Hardboard
E. Wet Process Hardboard
F. Wood Preserving - Water Borne or Nonpressure
G. Wood Preserving-Steam
H. Wood Preserving - Boulton
I. Wet Storage
J. Log Washing
K. Sawmills and Planning Mills
L. Finishing
M. Particleboard
N. Insulation Board

The prior categories cover both processes (i.e., barking and log washing) and products (i.e., plywood and particleboard) and an individual establishment may be impacted by more than one category if it is a multi-product plant or encompasses a regulated process as well as a product.

Industry Characteristics

The nonfurniture timber product processing industry encompasses a large, diversified and complex set of establishments and companies. The industry converts wood raw materials in a wide range of lumber, flat board, and other wood building and construction materials. Over 15,000 establishments (1979) are covered by this industry category including:

Type of plant	No. of plants
Sawmills	11,000
Millwork and finishing	3,000
Veneer and plywood	500
Wood preserving - NP, steam and boulton	476
Particleboard	75
Dry process hardboard (only)	16
Wet process hardboard (only)	11
Insulation board	10
Combined insulation and wet process hardboard	5
Total (approximate)	15,000 plus

The plants are located contiguously with the natural range of timberlands in the Pacific Northwest, Southeast, North Central and Northeastern United States. Their capacity will vary from small family operations to facilities employing a thousand workers. Capacity utilization generally varies from 80 to 95 percent although the recent housing market recession has dropped utilization rates much lower and caused several plant closings.

In 1981, industry value of shipments were over $18.5 billion. Real annual growth rates were growing at 4.1 percent per year from 1972-77 but showed declines of 6.2 percent per year for the 1978-81 period. Growth is expected to be positive in the near future, if the housing industry recovers.

Most of the nonfurniture timber processing industry is covered by the following SIC groups.

2421	Sawmills and Planning Mills
2435	Hardwood Veneer and Plywood
2436	Softwood Veneer and Plywood
2491	Wood Preserving
2492	Particleboard

Of these groups, the sawmill and planning mill group is the largest accounting for about two-thirds of the employment and value of shipment. Softwood veneer and plywood plants are the second largest group representing one-fifth of employment and value of shipments. Each of the other groups accounts for less than ten percent of the industry employment or shipments.

The method of waste disposal is highly variable, with some categories including all or predominately indirect dischargers. Detailed information on method of discharge is presented in the appendix.

Pollutants and Sources

Water use varies widely among the subcategories in the timber products processing industry. The major pollutants are chemicals leached from wood, particles from washing or cutting operations, and oils, phenols and metals from fishing and preserving operations. The major pollution parameters considered in developing treatment standards are BOD, COD, suspended solids, oil and grease, phenols, and metals.

Water use and major pollutants in each subcategory are summarized below.

The barking subcategory includes the operations which remove bark from logs. Barking may be accomplished by several types of mechanical abrasion or by hydraulic force. For the purpose of this regulation "hydraulic barking" means that method of barking wood that utilizes water at a pressure of greater than 68.0 atm (1000 psi) as the means of removing bark from logs. The product from the barking subcategory is normally used as a raw or feed material to other subcategories in the timber products processing category rather than being sold as a finished product. Wastewaters generated by the barking operation vary widely. Large volumes of water are used in hydraulic barking. Abrasion type barkers use less water and certain type barkers are operated dry. The wastewaters contain suspended solids and BOD5 in concentrations ranging up to 3,000 and 1,000 mg/l respectively.

The veneer subcategory includes the operations used to convert barked logs or heavy timber into thinner sections of wood known as veneer. Log conditioning, veneer dryer wash water, and cooling water are the main sources of wastewaters. The primary parameters contained in raw wastewaters are BOD5 and suspended solids. BOD5 loading may be as high as 2,500 kg/million sq m (515 lb/million sq ft) of board on a 9.53 mm (3/8 in) basis, and suspended solids may range as high as 29,000 kg/million sq m (6,000 lb/million sq ft) of board on the same basis from log conditioning steam vat wastewater.

The plywood subcategory includes the operations of laminating layers of veneer to form finished plywood. Plywood manufacturing is an almost entirely dry operation using water in significant quantities only for cleaning the glue mixing and glue application equipment. This wastewater may contain the various components in protein, urea or phenolic glues. Principal pollutants include suspended solids, nitrogenous materials, BOD5, phenols and formaldehydes. Both suspended solids and BOD5 concentrations may be extremely high ranging into hundreds of thousands of mg/l.

The dry process hardboard subcategory includes all of the manufacturing operations attendant to the production of finished hardboard from chips, dust, logs, or other raw materials using the dry matting process for forming the board mat. Water usage in dry process hardboard manufacturing is low, and waste dischargers are minimal. Sources of wastewater are log and chip washing, caul wash water, resin wash water, and cooling water. Typical wastewater flows are less than 2,000 l/day (500 gal/day).

The wet process hardboard subcategory includes all of the manufacturing operations attendant to the production of finished hardboard from chips, dust, logs, or other raw materials using the wet matting process for forming the board mat. The nature of the wet matting process in which the fibers are diluted from 40 percent consistency to less than 1.5 percent prior to mat formation, is such as to create volumes of wastewater in the range of 4.6 to 46 cu m/kkg (1,100 to 11,000 gal/ton). While the water use may vary from mill to mill, the main sources of wastewater are log wash, chip wash, and caul washwaters, fiber preparation, and mat formation (wet matting). The principal pollutants found in these wastewaters are BOD5 and suspended solids. BOD5 may reach 50 kg/kkg (100 lb/ton), and suspended solids loading usually averages under 19 kg/kkg (38 lb/ton).

The wood preserving--water borne or non-pressure subcategory includes all wood processes in which steaming or boultonizing is not the predominant method of conditioning, all non-pressure preserving processes, and all pressure or non-pressure processes employing water-borne salts. The actual volume of water used at a wood preserving plant is not static, but varies depending upon the condition of the stock being treated (either green or seasoned) and the size of the individual items. Wastewater characteristics vary with the particular preservative used, the volume of stock that is conditioned prior to treatment, the conditioning method used, and the extent to which effluents from retorts are diluted with water from other sources. Typically, wastewaters from creosote and pentachlorophenol treatments have high phenolic, COD, and oil content and may have a turbid appearance that results from emulsified oils. They are always acid in nature and the pH values usually fall within the range of 4.1 to 6.0. The COD for such wastes frequently exceeds 30,000 mg/1, most of which is attributable to entrained oils and to wood extractives (principally simple sugars) that are removed from wood during conditioning. The wastewater resulting from vat type treatment using water soluble salts is highly variable in both volume and pollutant content. As the source of this wastewater is primarily from drips, leaks and minor spills, it cannot be effectively characterized.

The wood preserving--steam subcategory includes all processes that use direct steam impingement on the wood as the predominant method of conditioning. Steam conditioning of wood produces a large volume of condensate containing extraneous components from the wood in addition to the wood preserving chemicals. The volume of wastewater may vary widely from day to day within the same processing facility; value ranges from 6,000 to 150,000 1/day (2,000 to 40,000 gal/day) have been recorded in a single facility. Pollutants are generally similar to those outlined for the wood preserving subcategory above.

The wood preserving--boultonizing subcategory covers those wood preserving processes which use the Boulton process as the method of conditioning stock. Boultonizing generates wastewaters similar in character to those in the steam subcategory. The volume, however, is substantially lower because the only source of process wastewater is the water removed from the wood during the conditioning step.

Wet storage includes storage of logs in estuaries and streams, log ponds, mill ponds and wet decks. Pollutants are washed off the surface of logs and leached from the wood. The principal pollutants of concern are COD, BOD, dissolved and suspended solids and phenols.

The processing operations of sawmills and planning mills have very limited process water requirements and the volumes of wastewater generated are not sufficient, with reasonable process management, to result in a process wastewater stream.

Finishing operations include gluing, application of surface coatings, and the application of sealers, stains, dyes, primers, and fillers, of either organic or inorganic nature. Pollutants typically include mercury and other metals, dissolved solids, phenols and organic resins, BOD, COD, and pH.

The primary sources of wastewater generation in the particleboard manufacturing industry are resin blender cleaning water, cleaning of additive storage tanks, caul cooling sprays, mat sprays, and fire control water. Pollutants typically include high BOD, COD, dissolved and suspended solids and phenols, nitrogen and phosphorus.

Insulation board manufacture generates a large volume of process water. Water may be used in a number of the following operations: chip washing, white water (i.e., water used in processing and carrying the wood fibers through the insulation board manufacturing process) finishing operations, cooling, seal water, fire control and housekeeping. Pollutants typically include BOD, COD, dissolved and suspended solids, and dissolved organic materials.

Treatment Technologies

Various treatment technologies can be used to achieve BPT, BAT, and NSPS guidelines. Technologies for the nine subcategories that are to achieve zero discharge under BPT or BAT include a combination of:

- Water conservation
- Recycling and reuse
- Waste stream segregation
- Inplant process changes, and
- Disposal processes such as spray irrigation, evaporation, incineration, and discharge to impoundments

Technologies for the five other subcategories have been chosen to reduce pollution loadings without completely eliminating discharges under BPT or BAT. These technologies have been chosen because standards requiring zero discharge would not be cost effective or economically feasible. Technologies and standards for these subcategories are summarized below.

Hydraulic barking, wet process hardboard, and insulation board plants are required under BPT to achieve numerical discharge limitations for BOD, suspended solids, and pH based on primary treatment followed by biological treatment. More stringent BAT standards have been withdrawn.

Wood preserving--steam facilities are required to achieve numerical discharge limitations for BOD, phenols, oil and grease, and pH, based on oil recovery, waste stream segregation and water conservation followed by one or more of the following:

- Biological treatment
- Oxidation
- Soil irrigation
- Evaporation; and
- Incineration of oil wastes

More stringent BAT standards have been withdrawn.

BPT and BAT standards for wet storage require minor modifications to existing facilities to eliminate discharge of debris.

NSPS treatment technologies are designed to achieve zero discharge for all subcategories except hydraulic barking and wet storage. In each of these categories NSPS technologies are the same as BPT technologies.

PSES for eleven subcategories are based on general pretreatment regulations. Technologies for these subcategories have not been specified.

The wood preserving--water borne or non-pressure subcategory must achieve zero discharge under PSES. This requirement is based on careful water management and recycling, as specified in the BPT standard.

The wood preserving--steam and wood preserving--boulton subcategories have PSES requirements which require facilities to meet numerical standards for oil and grease, copper, chromium and arsenic. These limitations can be met using in-place oil separation technology.

Costing Methodology

Cost estimates for each subcategory are derived from one or more of the following sources:

- Model plant costs from a Development Document
- Plant specific data from a Development Document
- Exogenous data from an Economic Analysis
- Exogenous data from a Federal Register notice

For each subcategory, the cost estimates reflect the currently promulgated regulations.

Total costs for each regulation affecting direct dischargers were estimated from a cost estimating power equation developed from model plant data or from exogenous data. Cost estimating equations were presented in the form $y=Ax^b$, in which:

y = capital or O&M costs, and
x = plant capacity

If more than one model plant was available for a technology, A and b were calculated using regression techniques. If only one model plant was available, values for A were calculated assuming b = .6 for capital costs and b = .8 for O&M costs.

Cost estimating equations, model plant data, exogenous data, and costing assumptions for direct dischargers in each subcategory are presented in the Appendix to this chapter.

Pretreatment standards more stringent than general pretreatment levels have been established for:

- Wood preserving - water borne or non-pressure
- Wood preserving - steam
- Wood preserving - boulton

Compliance costs for these subcategories are minimal and have been assumed to be zero.

The aggregate cost of compliance for all significantly impacted subcategories is presented in Table W7.1.1. These costs are developed from a combination of exogenous and model plant data depending on the subcategory. Specific cost data and assumptions are presented in the appendix.

Table W7.1.1. Timber product processing (nonfurniture)

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS)	BASE	1978	1983	1988	
CAPACITY: IN: CU FT/YR	.535E+11	.437E+11	.430E+11	.493E+11	
CAPITAL IN PLACE (KIP):	.0				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	262.02	7.29	7.29	0.0
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	35.10	117.22	104.33	209.62	330.09
O + M					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	20.89	61.42	60.97	123.81	209.42
ANNUAL CAPITAL + O+M	55.98	178.64	165.30	333.43	539.51
USER CHARGES	0.0	0.0	0.0	0.0	0.0
ALL ANNUAL COSTS	55.98	178.64	165.30	333.43	539.51

Chapter W7.2 Timber Product Processing: Wood Furniture and Fixture Manufacturing

Regulations

The wood furniture and fixture manufacturing industry is subject to BPT, BAT, NSPS, PSES, and PSNS regulations described in the Code of Federal Regulations Title 40, Part 429, Subparts O and P and as updated in the Federal Register (January 26, 1981). The two subparts are:

O. Wood Furniture and Fixture Production Without Water Wash Spray Booth(s) and Without Laundry Facilities

P. Wood Furniture and Fixture Production With Water Wash Spray Booth(s) or With Laundry Facilities

The specific regulations causing significant costs are BPT and NSPS for Subpart O and BAT and NSPS for Subpart P. Each of these regulations allow no discharge of process wastewater pollutants into navigable streams. BAT limitations for Subpart O equal BPT and thus generate no additional costs. BPT limitations for Subpart P are estimated to generate minimal costs. Dischargers to POTWs meet no special standards but must conform with general pretreatment standards provided in 40 CFR, Part 403.13.

Industry Characteristics

The two regulatory subcategories cover a diverse set of establishments that produce upholstered and nonupholstered wood household furniture; wood cabinets for televisions, radios, stereos, and sewing machines; wood office furniture; wood public building and related furniture; and wood partitions, shelving, lockers, and various other wood fixtures. Most of these special groups of producers are identified under the standard industrial classification (SIC) major group No. 25.

The wood household furniture segment has historically accounted for the majority of production in this industry as well as the largest number of plants.

The furniture and fixture manufacturers have experienced little or no growth in demand in recent years. Constant dollar sales for the period of 1972 to 1980 for wood furniture, upholstered furniture and wood cabinets have exhibited average annual changes of -0.2, 0.9 and -4.8 percent respectively. Only moderate growth is anticipated for the future and it is dependent on real economic growth in the U.S., a decline in interest rates and a recovery in the housing industry.

The total number of establishments covered by the SIC categories, 6,898, is larger than the number of wood product plants effected by wood furniture and fixture regulations as some of these plants produce only metal products. The number that produce only metal products is unknown and this study will use plant number estimates in development and economic documents to estimate costs. These sources indicate 6,097 plants would be covered by the wood furniture and fixture products.

Pollutants and Sources

Wastewater from wood furniture and fixtures manufacturing is produced primarily by three processes: glue cleanup, water wash spray booths, and laundry operations. Minor amounts of wastewater may also be produced by bleaching and steaming operations, and blowdown from air pollution scrubbers.

The wastewater parameters of primary significance in this industry include COD, total suspended solids, dissolved solids, pH, temperature and phosphorus. Parameters of secondary significance include BOD, phenols, color, oil and grease and inorganic ions.

For the purpose of establishing effluent limitations guidelines, the wood furniture and fixtures manufacturing industry has been divided into two subcategories, based on water usage. One subcategory includes those facilities which do not have water wash spray booths or laundry operations. Facilities in this subcategory typically have small wastewater loads. The other subcategory includes facilities which have water wash spray baths or laundry facilities (or both). Facilities in either subcategory may or may not include glueing, bleaching, steaming, or air pollution scrubbing operations.

Spray booths are used to filter air from finishing operations to provide fire and health protection. Dry booths, which use paper or fiberglass materials to collect overspray, are used in some plants. However, water wash spray booths are generally preferred because of safety and efficiency considerations.

The characteristics of the wastewater discharged from spray booths is dependent on the amount and type of overspray material captured by the water. The amount of material captured is a function of the efficiency of the booth in removing overspray from the air, the intensity of usage of the spray booth, and the length of time between drainages. The type of material used is dependent primarily upon the particular type of finishing operation being performed. The pH of these wastewaters is generally high because of alkaline dispersing agents which are used in finishing materials. Solids concentrations, COD and BOD are all high. Wastewater from spray booths are typically drained weekly.

Laundry facilities are used to clean rags used in finishing operations. Wastewaters from laundry machines have high pH and solids concentrations from the addition of soda ash, caustics, clay, and strong detergents to the wash water. The wastewaters are highly colored and contain high levels of COD and BOD.

Glueing operations occur during furniture assembly, prior to finishing. The glues, which may be applied manually or by automatic machines, may be solvent based or water based. Small volumes of wastewater may be generated during clean up of glueing operations. These waters have high COD and volatile solids concentrations, low pHs and low phenol concentrations.

Bleaching may be included in finishing operations to remove natural wood coloring by treating furniture pieces with a strong oxidizing agent such as hydrogen peroxide. Wastewaters from bleaching operations are generally small in volume, but high in solids concentrations and pH. They may also contain low concentrations of phenol.

Steaming may be used for wood bending operations. Wastewaters from steaming, which contain phenols, and high COD, BOD and solids concentrations, are generally small in volume.

Wet scrubbers are used at some plants to control air pollutant emissions from boilers. Continuous bleed off of scrubber waters may be required to avoid high solids build up and a resulting loss of efficiency. These wastewaters have high COD and solids concentrations.

Control Technologies

Wastewater has not been a major concern in the wood furniture and fixtures manufacturing industry. The Development Document estimates that 90 to 96 percent of all furniture factories either discharge their wastewaters to a municipal sewage system, contract to have them hauled away by a commercial disposal company or use a combination of these disposal methods.

The Development Document identified existing treatment or disposal technologies which could be used in this industry to achieve no discharge of wastewater to surface waters. The designated technologies are:

1. discharge to a publicly owned treatment works;
2. trucking wastewater to landfills;
3. incineration by spraying on hog fuel;
4. use of evaporation ponds; and
5. spray irrigation.

All of the technologies, except spray irrigation, can be used by both of the industry subcategories. Spray irrigation was considered applicable to only facilities with laundry facilities because their wastewaters are sufficiently biodegradable.

Table W7.2.1 summarizes the technologies required for BPT, BAT, and NSPS. The effluent limitations guidelines for the two subcategories are summarized briefly below.

Table W7.2.1. Technologies for wood furniture and fixture manufacturing

Subcategory	BPT	BAT	NSPS
O. Production without water wash spry booth(s) or laundry facilities	No discharge based on one or more of: • Discharge to POTW • Trucking waste to landfill • Incineration with hog fuel • Evaporation ponds	Same as BPT	Same as BPT
P. Production with water wash spray booth(s) or laundry facilities	• Remove settled sludge before discharging water portion • Settle water portion before discharge	No discharge based on one or more of: • Discharge to POTW • Trucking to landfill • Incineration with hog fuel • Evaporation ponds • Spray irrigation	Same as BAT

BPT. Facilities without water wash spray booths or laundry facilities are required to achieve no discharge using one or more of the technologies listed above. Facilities with water wash spray booths or laundries are required to meet a less stringent standard because of the adverse economic impact which could be expected from requiring these facilities to meet a no discharge requirement. Facilities in this subcategory are required to meet an effluent quality limitation which can be achieved with existing technology. They are required to minimize the effect of wastewaters on the environment by removing settled sludge and allowing the water portion to settle before discharging. Compliance cost data are not available; however, costs are assumed to be minimal.

BAT. Facilities in both subcategories are required to achieve no discharge by using one or more of the technologies listed above.

NSPS. Facilities in both subcategories are required to achieve no discharge by using one or more of the technologies listed above.

PSES and PSNS. Facilities in both subcategories are required to meet the general pretreatment requirements listed in 40 CFR Part 403.

Costing Methodology

Costs for the furniture and fixture manufacturers were determined from a model plant approach.

The Development Document presents capital and O+M costs for four model plants. One model plant represents the subcategory of facilities without water wash spray booths or laundry facilities. Three model plants represent the subcategory of facilities with water wash spray booths or laundry facilities.

Cost estimating equations of the form $y = Ax^b$ were used to estimate total costs (y represents capital or O+M costs, while x represents plant capacity). Data relating plant production to wastewater generation were not available from the Development Document; consequently, plant capacity has been expressed as gallons of wastewater per day.

The cost estimating equations for each model plant, costing assumptions, and the method for assigning size categories to model plants are summarized in the appendix.

The cost of compliance for wood furniture and fixture manufacturers are presented in Table W7.2.2. They are based on an industry population of 6,097 plants of which only about 10 percent were estimated to be direct dischargers.

Table WT.2.7. Timber product processing: wood furniture and fixture manufacturing

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)

	BASE	1978	1983	1988	
CAPACITY: IN: GALLONS/DAY	.1610E+07	.1610E+07	.1610E+07	.1658E+07	
CAPITAL IN PLACE (BCIP):	.0				

	1981	1972-78	1979-81	1979-88	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	16.25	0.0	0.0	0.0
BAT	0.0	12.76	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.22
PSES/PRETREATMENT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	29.01	0.0	0.0	0.22
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	2.33	5.73	5.73	11.46	19.09
BAT	1.50	6.63	4.50	8.99	16.99
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.05
PSES/PRETREATMENT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	3.83	12.36	10.22	20.45	36.13
O + M					
EXISTING PLANTS					
BPT	0.90	2.71	2.71	5.42	9.03
BAT	2.70	11.63	8.13	16.26	27.10
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.12
PSES/PRETREATMENT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	3.60	14.34	10.84	21.68	36.26
ANNUAL CAPITAL + O+M	7.43	26.69	21.06	42.13	70.39
USER CHARGES	0.00	0.00	0.00	0.00	0.00
ALL ANNUAL COSTS	7.43	26.69	21.06	42.13	70.39

Chapter W7.3 Gum and Wood Chemicals

Regulations

Effluent regulations for BPT were promulgated in interim final form on April 30, 1976. On the same date, effluent regulations were proposed for BAT, NSPS, and pretreatment for new sources. Costs are based on the promulgated BPT regulations and the other proposed regulations. This industry has been exempted from additional federal guidelines under Paragraph 8 of the 1976 settlement agreement with NRDC.

Industry Characteristics

While the majority of products included in this chapter are classified under SIC 2861, some products are also classified under SIC 2821 or SIC 2899 and some of the establishments producing these products are almost certainly classified the same way.

The Gum and Wood Chemicals Industry has been divided, for pollution control purposes, into six categories, as follows:

- Charcoal and charcoal briquets
- Gum rosin and turpentine
- Wood rosin, turpentine, and pine oil
- Tall oil rosin, fatty acids, and pitch
- Essential oils
- Rosin derivatives.

Charcoal and Charcoal Briquets. There are no wastewater discharges from the industry subsector, and it will not be discussed in detail, although it represents about 50 percent of the value of shipments of SIC 2861 establishments.

Gum Rosin and Turpentine. These products are produced by distillation of crude oleoresin (gum) collected from scarified longleaf and slash pine trees in southeastern United States. These plants are primarily located in Georgia or Alabama. It is estimated that 90 percent of the capacity is in establishments classified in SIC 2861 and 10 percent in SIC 2821.

The annual production of gum rosin and turpentine has been declining for several years. The collection of gum oleoresin is a labor-intensive operation, and this industry is expected to continue to decline.

Wood Rosin, Turpentine and Pine Oil. These products are obtained by distillation of oleoresin extracted from chipped stumps remaining after the harvesting of southern pine forests. Plants in this sector are located in Florida, Georgia, and Mississippi. It is estimated that 40 percent of production is in plants classified in SIC 2861, 40 percent in SIC 2899, and 20 percent in SIC 2821.

The annual production of wood rosin and steam-distilled turpentine (from stumps) has also been declining. The availability of stumps of a size that is economic for collection is decreasing as the inventory of sawmill size pine trees is diminishing in the Southeast. The production of natural pine oil from pine stumps is also declining, being displaced by the production of synthetic pine oil from turpentine.

Tall Oil Fractionation. Crude tall oil is a by-product of the kraft pulping process, although it is classified by the Bureau of the Census as a SIC 2861 product. The fractional distillation of crude tall oil yields tall oil rosin, tall oil fatty acids, and tall oil pitch. It is estimated that about 80 percent of the fractionation of crude tall oil occurs in establishments assigned to SIC 2861 and about 10 percent each in establishments assigned to SIC 2821 and SIC 2899.

As long as kraft paper is produced from pine trees, a potential supply of tall oil rosin and tall oil fatty acids should be available. This product is gradually replacing both gum rosin and wood rosin.

Essential Oils. These products are obtained by the steam distillation of scrap wood fines of the appropriate wood. The only essential oil included in the EPA documentation is cedarwood oil, which is classified in SIC 2899.

Rosin Derivatives. Most rosin is chemically modified to improve some of its properties prior to its ultimate use. The most common chemical modifications are probably condensation reactions with unsaturated organic acids or esterification with mono- or polyhydric alcohols. One reason for the decline in demand for rosin is that 30 pounds of fortified rosin is as effective in sizing paper as is 100 pounds of unmodified rosin. It is assumed that about 50 percent of rosin derivatives are produced in establishments classified in SIC 2821 and the remainder in establishments classified in SIC 2899.

Pollutants and Sources

The pollutant characteristics for the six categories of gum and wood chemicals are outlined below.

Char and Charcoal. No wastewater discharge has been identified from this process since it involves high temperature kiln distillation. One possible discharge is storm water runoff which carries suspended solids. This discharge can be controlled, however, by proper materials handling systems that reduce dust and solid materials in the plant area.

Gum Rosin and Turpentine. Three wastewater sources have been identified in this process. These are (1) rosin washing to remove soluble impurities, (2) distillate condensation, and (3) brine used to dehydrate the gum rosin. This waste load is largely generated during washing operations.

Wood Rosin, Turpentine, and Pine Oil. Process wastewater includes stripping as well as vacuum and steam condensates from the distillation operation. Another possible source of wastewater is from the washing of stumps for dirt removal. In a properly operated plant, however, this washwater is returned to a settling pond and reused after the solids have settled out. The solids are then periodically removed to a land fill.

Tall Oil Rosin, Pitch, and Fatty Acids. This is a highly efficient distillation process, with the primary source of wastewater being an acid wash given to the crude tall oil. Additional wastewater is accumulated during washdowns of process equipment.

Essential Oils. This process generates large amounts of wastewater since it is based primarily on steam distillation and the use of separators to recover the desired oils from the steam condensate. Large amounts of wastewater are involved, with a high waste load in the water.

Rosin Derivatives. These processes produce wastewater from a variety of point sources, including water of reaction, spray steam, vacuum jet steam, and condenser cooling water.

Control Technology

The Development Document identified 139 facilities in this industry category and found that approximately one-third used municipal sewage plants and were not covered by the final effluent guidelines. Approximately 20 percent of the plants had treatment ponds with no direct discharge, while 8 percent used the effluent for land irrigation in remote areas. Only approximately four percent had point-source discharges, and of these, eighty percent had no additional requirements to meet the BPT guidelines.

Treatment of wastewater consists of both in-plant and end-of-pipe treatment.

In-Plant Treatment. In-plant treatment techniques generally amount to more efficient housekeeping practices such as:

- Separating drainage lines so that effluent not requiring treatment (i.e. storm water) is handled separately.

- Improved efficiency of equipment washing procedures such as the use of several small quantities of rinsewater which can be recycled into the process.

- Use of techniques such as a squeegee to remove material before rinsing.

End-of-Pipe Treatment. Applicable end-of-pipe treatment processes include the use of primary clarifiers, aerated lagoons, oxidation ponds, dissolved air flotation, and combinations of these. Additional improvement in wastewater quality can be obtained through the use of filtration or carbon adsorption of the biological treatment plant effluent.

Costing Methodology

The cost of controlling the waste load in the effluent for five categories of the Gum and Wood Chemicals Industry has been estimated at three levels of control (BPT, BAT, and NSPS). To obtain the estimate, model systems were developed for the various subcategories, and cost estimates made based on end-of-pipe treatment. In-plant costs were not included because of their highly variable nature depending upon the purpose for which the plant was constructed.

Costs for end-of-pipe technologies were applied to the model plants, as applicable. Of the 51 plants included in the five subsectors when the regulations were promulgated, BPT costs were applicable to only one producer of rosin derivatives. BAT costs, however, will apparently be applicable to two wood chemicals plants, ten tall oil fractionation plants, and eight rosin derivatives plants. All other plants were in compliance with BAT regulations which were expected to be promulgated in 1980. It is assumed that all plants will be in compliance by 1984.

Costs derived for this industry are summarized in Table W7.3.1.

Table W7.3.1. Gum and wood chemicals

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (EIP): .786E+07

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	38.33	0.0	0.0	20.10
BAT	0.60	1.41	0.60	2.11	2.40
NEW PLANTS(NSPS)	2.29	3.77	6.50	11.67	19.73
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.90	43.51	7.11	13.78	42.23
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	5.04	21.61	15.12	30.23	48.78
BAT	0.27	0.84	0.64	2.03	4.21
NEW PLANTS(NSPS)	1.35	0.74	3.16	8.56	24.39
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	6.65	23.18	18.92	40.82	77.38
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	2.23	10.11	6.78	13.27	16.68
BAT	0.27	0.39	0.40	2.65	6.93
NEW PLANTS(NSPS)	0.82	0.45	1.92	5.21	14.89
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	3.32	10.95	9.09	21.13	38.50
ANNUAL CAPITAL + O+M	9.97	34.13	28.01	61.95	115.87
ALL ANNUAL COSTS	9.97	34.13	28.01	61.95	115.87

Chapter W7.4 Pulp, Paper and Paperboard

Regulations

Effluent control regulations affecting the pulp, paper and paperboard industry arise from the Clean Water Act and are codified in the Code of Federal Regulations, Title 40, Chapter 1, Subchapter N, Parts 430 and 431. Amendments to these regulations are announced in the Federal Register with the following announcements being critical for limitation guidelines on best practical technology (BPT), best available technology (BAT), new source performance standards (NSPS), pretreatment standards for existing sources (PSES) and pretreatment standards for new sources (PSNS).

- 39 FR 18747, May 29, 1974: Promulgated BPT guidelines for Part 430, Subparts A-E, and Part 431, Subpart A
- 42 FR 1407, January 6, 1977: Promulgated BPT guidelines for Part 430, Subparts F-V
- 47 FR 52006, November 18, 1982: Promulgated BPT guidelines for certain subcategories of 40 CFR Part 430 and Promulgated BAT, NSPS, PSES, and PSNS guidelines for 24 of 25 subcategories, (supersedes 46 FR 1430)
- 47 FR 52006, November 18, 1982: Proposed BAT and NSPS guidelines to limit PCBs where fine and tissue papers are made from deinked wastepaper.

Effluent control regulations exist for 26 industry subparts or subcategories within the pulp, paper, and paperboard industry. These include:

430 CFR

A. Unbleached Kraft
B. Semi-Chemical
C. [Reserved]
D. Unbleached Kraft-Neutral Sulfite Semi-Chemical (Cross Recovery)
E. Paperboard from Wastepaper
F. Dissolving Kraft
G. Market Bleached Kraft
H. BCT Bleached Kraft
I. Fine Bleached Kraft
J. Papergrade Sulfite (Blow Pit Wash)
K. Dissolving Sulfite Pulp
L. Grounded-Chemical-Mechanical
M. Groundwood-Thermo-Mechanical
N. Groundwood-CMN Papers
O. Groundwood-Fine Papers
P. Soda
Q. Deink
R. Nonintegrated-Fine Papers
S. Nonintegrated-Tissue Papers
T. Tissue from Wastepaper
U. Papergrade Sulfite (Drum Wash)
V. Unbleached Kraft and Semi-Chemical
W. Wastepaper-Molded Products
X. Nonintegrated-Lightweight Paper
Y. Nonintegrated-Filter and Woven
Z. Nonintegrated-Paperboard

431 CFR

A. Builders' Paper and Roofing Felt

Industry Characteristics

A total of 674 operating facilities have recently been identified as pulp, paper and paperboard producers. The industry is highly diversified utilizing both wood and nonwood pulp and paper materials to produce a wide variety of products including pulp, newsprint, printing and writing papers, unbleached and bleached packaging papers, tissue papers, glassine, greaseproof papers, vegetable parchment, special industrial papers, bleached and unbleached paperboard, felts, and building paper and board.

For analytical purposes, the industry is divided into three major segments: integrated, secondary fibers and nonintegrated mills. Mills in which pulp alone or pulp and paper or paperboard are manufactured on-site are referred to as integrated mills. Those mills in which paper or paperboard are manufactured but pulp is not manufactured on-site are referred to as nonintegrated mills. Mills which use wastepaper as the primary raw material to produce paper or paperboard are referred to as secondary fibers mills. While the virgin fiber source is predominantly wood (98 percent), secondary fiber sources such as wastepaper have gained increasing acceptance. Wastepaper recently accounted for over 22 percent of the fiber used in the United States.

In 1980, the value of shipments by the pulp, paper and paperboard industry was estimated at $30.7 billion dollars. Total employment was 220,000 and the quantity of shipments was 70.9 million short tons. Based on 706 facilities, shipments per plant would average about $43 million or 100,000 short tons in 1980. Shipments per employee would equal $140,000 or about 320 short tons.

The plants in the industry are also classified in SIC codes. These categories and the distribution of plants and shipments are as follows:

SIC Code	Title	% of Plants	% of Shipments
2611	Pulpmills	6	11
2621	Papermills	50	54
2631	Paperboard mills	36	33
2661	Building paper & building	8	2
		100	100

Historically, the pulp, paper and paperboard industry has been a solid performer with stable annual growth rates. The growth has evolved from a strong domestic market and active exporting. The current recession (1981-82) has depressed growth recently, but the overall long-term trend is favorable.

Pollutants and Sources

The production of pulp, paper, and paperboard involves four general manufacturing processes: (a) raw material preparation, (b) pulping, (c) bleaching, (d) papermaking. Water is used in each of the four major manufacturing processes as a medium of transport, a cleaning agent, and as a solvent or mixer.

Depending on the form in which the raw materials arrive at the mill, log washing, bark removal, and chipping may be employed to prepare wood for pulping. These processes can require large volumes of water. The use of dry bark removal techniques or the recycle of wash water or water used in wet barking operations significantly reduces water consumption.

Pulping is the operation of reducing a cellulosic raw material into a pulp suitable for further processing into paper or paperboard or for chemical conversion. The primary types of pulping processes are:

(a) Mechanical pulping (groundwood); and

(b) Chemical pulping (alkaline, sulfite, or semi-chemical processes).

After pulping, the unbleached pulp is brown or dark colored due to the presence of lignins and resins or because of inefficient washing of the spent cooking liquor from the pulp. In order to remove these color bodies from the pulp and to produce a light colored or white product, it is necessary to bleach the pulp.

In stock preparation, the pulp is resuspended in water. Further mixing, blending, and the addition of non-cellulosic materials are necessary to prepare the stock for making most paper or board products. The various papermaking processes have basic similarities regardless of the type of pulp used or the end-product manufactured. A layer of fiber is deposited from a dilute water suspension of pulp on a fine screen, called the "wire." This layer is then removed from the wire, pressed, and dried. The two basic types of machines used to make paper or paperboard are a Fourdrinier machine or a cylinder machine.

As indicated above, the pulp, paper, and paperboard industry is a high water-use industry. Major uses of water are similar throughout the industry although the amount used varies from segment to segment. The two methods of wastewater discharge include direct discharge to navigable waters and indirect discharge to a publicly owned treatment works (POTW). At some mills, recycle systems or evaporation techniques are used so that no wastewater is discharged. It has been estimated that wastewater discharges from the industry total 4.2 billion gallons per day. The wastewater characteristics differ from subcategory to subcategory due to the varying nature of processes employed and/or products manufactured. In general, the wastes are complex mixtures of natural and synthetic organic materials and inorganic chemicals. Pulping wastes, which are the major portion of the industry's water pollution, come from grinding, digester cooking, washing, bleaching, thickening, deinking, and defibering. These wastes contain sulfite liquor, fine pulp, bleaching chemicals such as zinc hydrosulfite and chlorine, mercaptans, sodium sulfides, carbonates and hydroxides, sizing, casein, clay, ink, dyes, waxes, grease, oils, fibers, and chlorophenolics from biocide and slimicide formulations. Papermill wastes originate in water which passes through the screen wires, showers, and felts of the paper machines, beaters, regulating and mixing tanks, and screens. The paper machine wastes contain fine fibers, sizing, dye, and other loading material. The most important pollutants associated with the production of pulp, paper, or paperboard which are controlled by BPT, BAT, NSPS, PSES, and PSNS regulations are:

1. Toxic pollutants--chloroform, zinc, trichlorophenol, and pentachlorophenol; and
2. Conventional pollutants--BOD5, TSS, and pH.

Control Technologies

The two major technological approaches used to reduce wastewater and/or wastewater pollutant discharge in the pulp, paper, and paperboard industry are: (a) production process controls; and (b) effluent treatment technology. Production process controls are those technologies implemented in-plant to reduce the effluent volume and pollutant loading discharged from the manufacturing facility. Effluent treatment technologies are those end-of-pipe treatment systems used to reduce the discharge of pollutants contained in mill effluents. In most instances, pollution abatement programs developed for use at individual mills include both approaches.

Production Process Controls. Available methods for reduction of pollutant discharges by internal measures include effective pulp washing, chemicals and fiber recovery, treatment and reuse of selected waste streams and collection of spills and prevention of "accidental discharges." Internal measures are essentially reductions of pollutant discharges at their origins and usually result in the recovery of chemicals, by-products, and the conservation of heat and water.

Effluent Treatment Technologies. Effluent treatment technologies are those processes which are employed after the effluent leaves a mill for the reduction of suspended solids and BOD5 and adjustment of pH before it enters the receiving waters. Many types of wastewater treatment systems are employed at mills in the pulp, paper, and paperboard industry and can include:

- Screening
- Pumping stations
- Primary clarification
- Sludge lagoon
- Biological treatment
  - Aerated stabilization basis (ASB)
  - Activated sludge
  - Oxidation basins
- Equalization basins
- Secondary clarification
- Neutralization
- Flotation thickening
- Sludge dewatering
- Foam control
- Outfall sewers
- Diffusers

Control Technologies for Compliance with Regulations

The control technologies are based on regulations in the Code of Federal Regulations, revised as of July 1, 1981, and promulgated and proposed regulations in the Federal Register of November 18, 1982. The regulations promulgated in the Federal Register notice include BPT and revised BAT regulations and supersede prior NSPS, PSNS, and PSES regulations for the pulp, paper, and paperboard industry. The proposed FR regulations are to control PCBs from deinked wastepaper. Table 1 (in the Appendix) lists the status of the effluent limitations guidelines, pretreatment standards, and new source performance standards which were used in selecting control technologies for compliance.

BPT Control Technology. The control technologies selected for compliance with BPT effluent limitations are a combination of in-plant and end-of-pipe control technologies. In-plant technologies can include additional spill collection, low volume-high pressure cleaning showers, collection and reuse of vacuum pump waters, and water reduction. End-of-pipe technologies include bar screens, mechanical clarifiers, emergency spill basins, one and two stage biological treatment, foam control, sludge lagoons and sludge dewatering. The specific technologies used for coating of the various subcategories are listed in the appendix to this chapter. It should be noted that all of the end-of-pipe technologies developed for Phase I and II subcategories would probably not be implemented by a mill. The end-of-pipe technologies developed are merely guidelines for the types of technologies that work for a subcategory.

The pollutant parameters regulated by BPT are BOD, TSS, and pH for all subcategories and zinc for those mills using zinc hydrosulfite as a bleaching agent in the manufacturing process in the Grounded-Chemical-Mechanical, Groundwood-Thermo-Mechanical, Groundwood-CMN Papers, and Groundwood-Fine Papers Subcategories.

BAT Control Technology. In general, BAT uses BPT as a basis for further improvements. With one exception, the additional technology considered BAT is chemical substitution for the control of toxic pollutants. Slimicides and biocides containing trichlorophenol and pentachlorophenol can be replaced with formulations that do not contain toxic chemicals. The exception is the proposed control of PCBs for the Deink-Fine and Deink-Tissue subcategories which requires the best performing existing technology for all Deink subcategory mills.

The pollutant parameters proposed for regulation by BAT are trichlorophenol and pentachlorophenol for all subcategories; zinc for the Groundwood Subcategories; chloroform for the Dissolving Kraft, Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft, Papergrade Sulfite (both drum wash and blow pit wash), Dissolving Sulfite Pulp, Soda, and Deink Subcategories; and PCB (1242) for the Deink Subcategories. In the Groundwood Subcategories, the proposed BAT limitations for zinc are identical to BPT limitations for control of this toxic metal. It has been determined that zinc discharges from mills in the Groundwater Subcategories have been greatly reduced to levels in compliance with BPT effluent limitations guidelines through the substitution of the bleaching chemical sodium hydrosulfite for zinc hydrosulfite. The control of chloroform is based on the application and proper operation of biological treatment, which forms the basis of existing BPT regulations. The necessity for additional end-of-pipe treatment or production process controls is thus not required except for best performing existing technology to control PCBs from Deink mills.

NSPS Control Technology. The control technology required for compliance with New Source Performance Standards (NSPS) is the best available demonstrated technology. These include in-plant and end-of-pipe treatment technologies for the integrated segment, nonintegrated segment, and secondary fibers segment of the pulp, paper, and paperboard industry.

The pollutant parameters promulgated for regulation by NSPS are BOD, TSS, pH, trichlorophenol and pentachlorophenol for all subcategories, zinc for the Groundwood Subcategories, and chloroform for the Dissolving Kraft, March Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft, Papergrade Sulfite (both drum wash and blow pit wash), Dissolving Sulfite Pulp, Soda, and Deink Subcategories. NSPS pollutant parameter regulations are proposed for PCBs for the Deink Subcategory. Significant costs will originate only from the control of BOD, TSS, and pH based on information in the November 18, 1982 Federal Register.

PSES Control Technology. The treatment technology for complying with Pretreatment Standards for Existing Sources (PSES) is based on chemical substitution. Slimicide and biocide formulations containing trichlorophenol and pentachlorophenol can be replaced with formulations that do not contain these toxic pollutants. Zinc hydrosulfite, a chemical used to bleach groundwood pulps, can be replaced with sodium hydrosulfite.

The pollutant parameters proposed for regulation by PSES are trichlorophenol and pentachlorophenol for all subcategories and zinc for the Groundwood Subcategories.

PSNS Control Technology. The treatment technology required for compliance with Pretreatment Standards for New Sources (PSNS) is the same as that for PSES described above. The pollutants controlled are also the same as those for PSES listed above.

Costing Methodology

Water pollution control costs to the pulp, paper, and paperboard industry for compliance with effluent limitations and new source performance standards were obtained exogenously from the Economic Analyses, Development Documents, and the Federal Register. These documents cover various guidelines, industry subcategories and specific phases of regulatory action including:

- BPT - Phase I Subcategories A-E and Builders' Paper
- BPT - Phase II Subcategories F-V Except Builders' Paper
- BPT - Four new proposed subcategories
- BAT - Proposed PCB standards for the Deink Subcategory

- NSPS - BOD5, TSS, and pH standards for all subcategories
- BAT except Deink, PSES & PSNS - Regulatory guidelines generally cause minimal or insignificant costs

The exogenous costs of compliance developed from the reports and used as input for the ABTRES costing model are presented below. The exogenous cost data are primarily based on existing plant data that were obtained from EPA "308" surveys. Model plants were not utilized in cost aggregation. These data are net costs as costs for capital-in-place were also deducted on an exogenous basis.

Regulations	Base year of costs	Capital costs ($ million)	O&M costs ($ million)
Phase I - BPT	1971	368.1	51.3
Phase II - BPT	1975	1,672.0	191.0
Wastepaper molded-BPT	1982	8.4	0.72
Deink-BAT	1982	29.4	3.21
NSPS	1982	27.7	3.51
BAT	--	---------insignificant--------	
PSES	--	---------insignificant--------	
PSNS	--	---------insignificant--------	

The cost of compliance for the pulp, paper and paperboard industry derived from the previous input data are presented in Table W7.4.1.

Table W7.4.1. Pulp, paper and paperboard

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (BIPP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	8.01	3214.10	8.01	36.02	194.41
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	423.62	1350.15	1268.77	2545.16	4136.00
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS(NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	386.64	1232.25	1158.54	2323.05	3959.58
ANNUAL CAPITAL + O+M	810.26	2582.40	2427.31	4868.21	8095.58
ALL ANNUAL COSTS	810.26	2582.40	2427.31	4868.21	8095.58

Chapter W8. Foods and Agricultural Industries

For the purpose of this report the Foods and Agricultural Industries are defined to include those establishments which prepare or process farm or ranch products for delivery to an ultimate consumer. Farms and ranches are specifically excluded; these are discussed in Chapter 10 under Nonpoint Sources. The industries covered in this chapter are:

- Grain Milling
- Sugar Processing
- Canned and Preserved Fruits and Vegetables
- Canned and Preserved Seafood
- Dairy Products Processing Industry
- Feedlots Industry
- Meat Products Processing
- Leather Tanning and Finishing Industry

Costs for the abatement of water pollution for these sectors are summarized in Table W8. These costs and other data are repeated below in the respective sections of this chapter, together with the assumptions specific to the industry and other details.

TABLE W 8. FOOD & AGRICULTURAL
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

CHAPTER	INDUSTRY	INVESTMENT 1981	INVESTMENT 1972-78	INVESTMENT 1979-81	INVESTMENT 1979-84	INVESTMENT 1981-90
W 8. 1	GRAIN MILLS	2.41	14.25	6.94	14.82	33.49
W 8. 2	SUGAR PROCESSING	16.66	47.63	43.62	80.09	99.55
W 8. 3	FRUITS & VEGETABLES	4.21	881.16	12.22	22.60	270.06
W 8. 4	CANNED & PRESERVED SEAFOOD	5.35	62.56	15.72	27.56	49.66
W 8. 5	DAIRY PRODUCTS	11.64	243.91	33.35	70.02	214.87
W 8. 6	FEEDLOTS	7.03	96.07	20.50	44.39	138.67
W 8. 7	MEAT PRODUCTS	86.09	107.92	254.47	397.91	499.81
W 8. 8	LEATHER TANNING	28.58	0.0	50.43	154.30	145.46
	TOTAL INVESTMENT	161.97	1453.51	437.26	811.69	1451.57

CHAPTER	INDUSTRY	ANNUAL COSTS 1981	ANNUAL COSTS 1972-78	ANNUAL COSTS 1979-81	ANNUAL COSTS 1979-84	ANNUAL COSTS 1981-90
W 8. 1	GRAIN MILLS	5.01	10.04	13.33	32.08	80.31
W 8. 2	SUGAR PROCESSING	22.00	29.71	55.58	140.57	321.91
W 8. 3	FRUITS & VEGETABLES	1147.97	3650.08	3443.83	6888.09	11479.43
W 8. 4	CANNED & PRESERVED SEAFOOD	18.37	39.67	51.70	113.01	228.64
W 8. 5	DAIRY PRODUCTS	43.80	129.89	125.60	269.42	530.88
W 8. 6	FEEDLOTS	33.03	92.25	93.08	205.39	442.99
W 8. 7	MEAT PRODUCTS	148.61	133.20	341.92	924.58	2281.99
W 8. 8	LEATHER TANNING	11.80	0.0	18.49	113.52	350.23
	TOTAL ANNUAL COSTS	1430.59	4084.83	4143.53	8686.66	15716.37

Chapter W8.1 Grain Milling

Regulations

In August, 1979, BCT was defined as being equal to BAT for all but one of the subcategories in this industry. BAT regulations for bulgur wheat flour milling were found to be unreasonable and were suspended. Pending revision of these regulations and the publication of new cost data, this chapter has not been updated. Only BPT and NSPS regulations have been costed for this chapter.

Grain Milling Industry (Phase I)

For purposes of establishing water effluent guidelines, Phase I of the grain milling industry was divided into four major subcategories: wet corn milling, dry corn milling, bulgur wheat flour milling, and parboiled rice milling. Two other subcategories, normal wheat flour milling and normal rice milling, have been excluded because they do not use process water.

Industry Characteristics. Wet corn milling comprises three basic process operations: milling, starch production, and syrup manufacturing. The finished products of starch and corn sweeteners are used for paper products, food products, textile manufacturing, building materials, laundries, home uses, and miscellaneous operations.

Dry corn milling processes separate the various fractions of corn, namely the endosperm, hull, and germ. These fractions are later ground and sifted after separation. The final products include: corn meal, grits, flour, oil, and animal feed.

Bulgur wheat flour milling produces parboiled, dried, and partially debranned wheat for use in either cracked or whole grain form. Bulgur is produced primarily for the Federal Government as part of a national effort to utilize surplus wheat for domestic use and for distribution to underdeveloped countries.

Parboiled rice milling utilizes rice that is carefully cleaned, parboiled by soaking in water, and then cooked to gelatinize the starch. After cooking, the water is drained and the parboiled rice is dried before milling. The bran and germ are later separated from the milled rice. The final product has superior nutritive qualities because vitamins from the bran are forced into the endosperm.

Shipments of wet corn milling products are expected to increase at an annual rate of 7.5 percent. The use of dry corn milling products directly in foods has declined significantly over the past 20 years but this decline has been offset by the growing use of the products as ingredients in processed foods. Total production has remained about constant. Consumption of bulgur wheat flour milling products has been increasing in developing nations due to the high nutritional values of bulgur wheat. Rice milling including parboiled products are about 60 percent exported and 40 percent used for domestic trade. An increase in rice mill products of 2.3 percent is expected annually from 1976 to 1985.

Pollutants and Sources. Principal wastewater sources in wet corn milling are modified starch washing, condensate from steepwater evaporation, mud separation, and syrup evaporation. Dry corn milling process wastes originate from washing of corn and infrequent grain rail car washing. Bulgur wheat flour milling process wastewater stems from steaming and cooking of bulgur, although these quantities are relatively small. Parboiled rice milling process wastewater stems from steeping or cooking operations, and at least one plant uses wet scrubbers for dust control, which generates an additional source of wastewater.

The basic parameters used to define wastewater characteristics are BOD_5, suspended solids, and pH. About one-fourth of the wet corn milling plants discharge directly into surface water. The majority of the plants in the other subcategories discharge into municipal systems.

Control Technology and Costs. Except for wet corn milling, little attention has been focused on either in-plant control or treatment of wastewaters. In many instances, the treatment technologies developed for wet corn milling can be transferred to the other industry subcategories. Current in-plant control consists of water recycling, cooling systems (barometric condensers), and some plants use biological treatment (activated sludge).

Best practicable technology for the four subcategories consists of the following:

- Wet corn milling--Equalization of flows, activated sludge treatment, and stabilization lagoon
- Dry corn milling--Primary sedimentation and activated sludge treatment
- Bulgur wheat flour milling--Activated sludge treatment
- Parboiled rice milling--Activated sludge treatment.

New source performance technology for the four subcategories is deep bed filtration in addition to BPT.

Since the wet corn milling industry contributes the largest amount of wastewater discharges, control costs for this industry are of primary concern.

Grain Milling Industry (Phase II)

For purposes of establishing water effluent guidelines, the Phase II segments of the grain milling industry consist of three major subcategories: animal feed, breakfast cereal (ready-to-eat and hot cereal), and wheat gluten and starch. Animal feed and hot cereal mills do not generate any significant process wastewaters.

Industry Characteristics. For the purpose of estimating costs, the ready-to-eat cereal subcategory has been divided according to average daily production into plant classes consisting of: small (91 metric tons or 100 short tons per day), medium (230 metric tons or 250 short tons per day), and large (540 metric tons or 600 short tons per day). The division of the wheat gluten and starch subcategory daily production values is: small (30 metric tons or 33 short tons per day), medium (45 metric tons or 50 short tons per day) and large (60 metric tons or 66 short tons per day).

The animal feed, breakfast cereal, and wheat gluten and starch industries all utilize products from the basic grain processing mills for raw materials. Grain and grain milling by-products are the chief ingredients in animal feed. The manufacture of breakfast cereals utilizes both milled and whole grain, particularly corn, wheat, oats, and rice. Wheat gluten and starch manufacturing employs wheat flour as its raw material.

Animal feed manufacturing comprises: ingredients mixing, meal production, pelleting, cooling and drying pellets, rolling, and finally, formation of granules. Of all the cereal grains produced in the U. S., only about 15 percent is used directly as food for human consumption. The vast majority of the grain harvest is used to feed poultry and livestock.

Breakfast cereals can be broadly classified as either hot cereals or ready-to-eat cereals. Hot cereals require cooking before serving and are normally made from oats or wheat. Ready-to-eat cereal manufacturing methods vary depending on the type of cereal. Raw materials include whole grain wheat and rice, corn grits, oat flour, sugar, and other minor ingredients. The general processes involved include ingredient mixing, cooking, drying, forming (either flaking or extruding), toasting or puffing, and vitamin addition.

The wheat starch industry may be properly termed the wheat gluten and starch industry, as the gluten presently brings a higher economic return than the starch. Basically, wheat starch manufacturing involves the physical separation and refinement of the starch and gluten (protein) components of wheat flour.

Pollutants and Sources. Animal feed and hot cereal manufacturing plants utilize little or no process water and generate no wastewaters. Water is used quite extensively in ready-to-eat cereal manufacturing plants. The various operations where water is used include: grain tempering, flavor solution makeup, cooking, extrusion, and coating. Water is also used for cooling, flaking, and forming rolls; extruders; and for wet scrubbers. Most of the unit processes do not result in process wastewaters. Only the cooking operation in shredded cereal manufacturing generates a continuous or semi-continuous waste stream. In wheat starch manufacturing, process water is used for dough making, dough washing, backwashing of screens, and counter-current washing of centrifuge discharges. Water is also used for plant cleanup and for auxiliary systems such as boiler feed water and cooling.

The basic parameters used to define wastewater characteristics are BOD_5, suspended solids, and pH. For all practical purposes, all of the plants in both the ready-to-eat cereal and wheat gluten and starch categories discharge to municipal systems.

Control Technology and Costs. The costs for the industry categories in this group include increased user charges for plants discharging to municipal sewerage. New plants may be expected to pretreat their process waste before discharging to municipal systems or to provide secondary treatment.

Best practical technology (BPT) for the ready-to-eat cereal subcategory is activated sludge treatment and sedimentation. Activated sludge treatment and equalization is required for wheat gluten and starch plants.

Abatement costs for Phases I and II of the Grain Milling Industry are combined in Table W8.1.1.

Table W8.1.1. Grain milling

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.292E+08 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	4.46	0.0	0.0	1.50
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	2.41	9.79	6.94	14.82	31.99
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.41	14.25	6.94	14.82	33.49
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.59	1.87	1.76	3.52	5.83
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	2.20	3.75	5.66	14.31	38.53
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.79	5.62	7.42	17.82	44.36
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.42	1.34	1.27	2.53	4.22
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	1.80	3.07	4.64	11.72	31.73
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.22	4.42	5.91	14.25	35.95
ANNUAL CAPITAL + O+M	5.01	10.04	13.33	32.08	80.31
ALL ANNUAL COSTS	5.01	10.04	13.33	32.08	80.31

Chapter W8.2 Sugar Processing

Regulations

BPT standards have been promulgated for the seven subcategories included in this industry, although they were later revoked for one of the subcategories. BAT, NSPS, and pretreatment standards have been promulgated for three of the subcategories but only proposed for the other four. This chapter has not been updated pending promulgation of the remaining regulations and publications of applicable cost data.

Sugar Processing, Phase I--Cane Sugar Refining

Industry Characteristics. Raw sugar consists primarily of crystals of sucrose with small percentages of dextrose and levulose. Various impurities such as particulates, organic and inorganic salts, and microorganisms are also present. A film of molasses is contained on raw sugar. Crystalline raw sugar is washed to remove part of the molasses film, put into solution, taken through various purification steps, and finally recrystallized.

The major processes involved in cane sugar refining are: (1) melting, (2) clarifying, (3) decolorizing, (4) evaporating, (5) crystallizing, and (6) finishing. Melting is the first step in which raw crystals are put into solution by heating; this syrup is then fine screened to remove insoluble materials. In the clarifying step, screened melt liquor which still contains fine suspended and colloidal matter is treated chemically to cause these to precipitate. Decolorizing involves the physical adsorption of impurities; bone char is the primary adsorbent used to remove color. The object of the evaporating process is concentration of the decolorized sugar liquor and sweet water (water containing syrup); this is done in continuous evaporators. Crystallizing of the concentrated sugar liquor and sweet waters is done in batch evaporators called vacuum pans. Finishing is a drying or granulation step in which moisture is removed and the crystals are separated and later cooled and fine screened.

The molasses produced as a by-product of cane sugar refining is used as a sweetener, as an ingredient in animal feed, for making alcohol, for organic chemicals, and for other uses.

The cane sugar refining industry consists of two subcategories: (1) crystalline cane sugar refining, and (2) liquid cane sugar refining. Liquid sugar production is essentially the same as crystalline sugar production except that the primary product is not recrystallized.

The domestic sugar industry in recent years has not been very profitable with the exception of 1974, when the prices of sugar were very high. Currently, there is very keen competition from foreign sugar producers. Although a price-support system has recently been activated, a resurgence of the industry is not expected. Rather, it is believed that this will protect the industry as it is and will not encourage increased acreage of cane or the building of new sugar mills. As a matter of fact, in a period from 1973 through 1976, three mills closed in Louisiana, three in Hawaii, and the rated capacity in Puerto Rico declined. For these reasons, the study used a zero growth rate.

Pollutants and Sources. Major process wastewaters from cane sugar refining include char (activated carbon process water from nonchar refineries) wastewater from decolorization. Most of the waste streams produced in other processes are recovered as low-purity sweet water. Wastewater from barometric condenser cooling is usually recirculated and represents a minor waste stream.

Wastewater contaminating pollutants are associated with (1) the water used as an integral part of the process (primarily the decolorizing steps of either bone char or activated carbon washing), (2) the result of entrainment of sucrose into barometric condenser cooling water, and (3) the water used to slurry the filter cake.

Parameters under effluent guidelines for meeting BPT, BAT, and NSPS include BOD_5, suspended solids, and pH. Additional parameters of significance to the industry include COD, temperature, sucrose, alkalinity, total coliforms, fecal coliforms, total dissolved solids, and nutrients.

Currently, 50 percent of crystalline sugar refineries and 60 percent of liquid cane sugar refineries discharge into municipal systems. On an average 38,400 liters per metric ton (9,200 gallons per short ton) of wastewater is discharged from crystalline sugar refineries; the corresponding figure is 18,800 liters per metric ton (4,500 gallons per short ton) from liquid cane sugar refineries.

Control Technology. Current technology for control and treatment of cane sugar refinery wastewaters consists primarily of process control (recycling and reuse of water, preventing sucrose entrainment in barometric condenser cooling water and recovering sweet waters), impoundage (land retention), and disposal of process water to municipal sewerage systems.

Best Practicable Technology (BPT) consists of a combination of in-plant changes and end-of-pipe treatment. In-plant changes include: (1) collection and recovery of all floor drainage, (2) use of improved baffling systems, demisters, and/or other control devices in evaporators to minimize sucrose entrainment in barometric condenser cooling water, and (3) dry handling of filter cakes after desweetening, with disposal to sanitary landfills, or complete containment of filter cake slurries. End-of-pipe treatment consists of biological treatment of all wastewater discharges other than uncontaminated (noncontact) cooling water and barometric condenser cooling water.

Best Available Technology (BAT) is essentially the same as BPT but, in addition to BPT, the following are applicable: (1) recycle of barometric condenser cooling water by utilizing either a cooling tower or pond, (2) biological treatment of the (assumed 2 percent) blowdown from the cooling system, and (3) sand filtration of effluent from the biological treatment system. Essentially the same control technology is applicable to both crystalline and liquid cane sugar refineries.

Sugar Processing, Phase II--Raw Sugarcane Processing

Industry Characteristics. Sugarcane milling (SIC 2061) involves the conversion of freshly harvested sugarcane into raw sugar and molasses. Because the quality of the juice drops rapidly after harvest, sugar mills are located close to the fields in which the cane is grown. On the other hand, refineries, which convert raw sugar to refined sugar, are typically located close to the market area. Only a few cane mills are integrated with a refinery. (Pollution problems in sugarcane refining are discussed elsewhere.)

The processes carried out in the sugar mill are conceptually rather simple. The cane is hauled into the mill, weighed, and dumped. In areas where collection procedures cause large amounts of dirt and rocks to be included in the material brought to the mill (Hawaii, Louisiana, and Puerto Rico), the cane is usually cleaned by blowing air through it and washing it with water. Rocks are removed by passing the material over grates. (In some regions of Hawaii, it is not unusual for 50 percent of the gross weight of cane brought to the mill to be rocks, dirt, and field trash such as leaves.) The clean cane is then chopped or run through a hammermill and then crushed with rollers that squeeze much of the juice out. This is followed by 4-6 three-roll mills that squeeze out almost all the remaining sugar. Water is added at the last mill to help wash the last of the sugar from the fiber. This juice is then used to wash the fiber in earlier stages so that a counter-current extraction is achieved. The bagasse from the last mill has about 50 percent moisture and is sent to the boiler or to the bagasse house. The bagasse can be used as boiler fuel, processed to make the chemical furfural, or used in making wallboard or paper. In some regions where fuel is cheap or where the bagasse exceeds the needs for the boiler and where no by-product industry exists, unwanted bagasse is either landfilled or dumped in the ocean.

The fresh cane juice is heated and treated with lime to precipitate impurities. The precipitate, "mud", is separated from the clarified juice by decantation and vacuum filtration of the sludge from the clarifier. The mud, which is mostly inorganic material but which contains sugar, wax, organic salts, and fine bits of bagasse, is frequently a disposal problem. The clarified juice is next evaporated using multiple-effect evaporators to reduce its volume and increase the concentration of sugar. After the solution is partly evaporated, it is conveyed to vacuum pans in which it is further concentrated. The final concentrated sugar solution in the vacuum pans is seeded with crystals of pure sugar and, because the solution is supersaturated, the sugar grows around these seeds, excluding the water and impurities. The final product is raw sugar, which is centrifuged, washed with hot water, and discharged. It is pure enough to be free-flowing even though it has a light brown color. The centrifugate, which is known as blackstrap molasses, contains roughly 44 percent sugar but also contains dissolved salts and water. It is sold for animal feed or as a starting material for rum or other fermentation products.

Pollutants and Sources. A number of points in the process can give rise to water pollution. The greatest problem in areas with dirty cane is the handling of the cane washings. In the washing process, some sugar is lost to the wash water and organic particles are suspended in it, each of which gives rise to biological oxygen demand. In addition, there are large amounts of suspended dirt and dissolved inorganic solids. In areas where irrigation is practiced, the cane wash water can be used for irrigation. In other areas, storage in ponds followed by appropriate treatment is needed. The solid trash, rocks, etc., are landfilled.

The mud which is removed from the vacuum filters contains about 75 percent water which has dissolved organic and inorganic material in it. To avoid problems some mills dry the mud, which can then be returned to the fields. In other sugar mills, the filter mud is slurried and discharged to waterways, which can present a significant water problem.

In the final stage of the multiple-effect evaporator, and in the vacuum pans, barometric condensers are used; that is, cooling water is mixed directly with the steam to condense it and create a vacuum. This allows sugar particles that are entrained in the steam to become mixed into the condenser water, producing a biological oxygen demand when that water is ultimately discharged. Condenser water can amount to as much as 25 thousand liters per metric ton (6 thousand gallons per short ton) of cane processed and can have a BOD_5 loading of up to 1.5 kg per metric ton (3 pounds per short ton) of cane processed. When this water is used for irrigation, there is no significant problem. On the other hand, in areas where irrigation is impractical, the water produces a pollution problem if discharged into navigable waterways. Control can be obtained by impoundment followed by biological treatment before discharge. Alternatively, the condenser water can be used in cane washing. If the cane wash water is collected and treated it can be recycled to the condenser.

Minor sources of problems are the water from washing the floors of the sugar mill which contain sugar from the spills and spatters that continually occur in the mill as well as mud tracked in on boots. The boiler systems can also give rise to pollutants. The water in which the ash is slurried for removal from the boiler can cause problems as well as the blowdown water from the boiler itself.

Control Technology. Recommended BPT, BAT and NSPS control technologies for cane sugar processing states are discussed below.

BPT Technology for Louisiana. Improved controls and practices to reduce pollution such as the reduction of entrainment of sucrose in the barometric condenser cooling water are recommended. The use of settling ponds to remove solids from the wash water and biological treatment for the effluent from settling ponds and all other waste streams except barometric condenser cooler water and excess condensate are recommended.

BAT and NSPS Technology--Louisiana. Recycling of barometric condenser cooling water and cane wash water and biological treatment of blowdown and miscellaneous waste streams is suggested.

BPT, BAT, and NSPS Technology--Florida and Texas. The containment of all wastewaters is required except when rainfall causes an overflow from a facility designed to contain wastewaters.

BPT, BAT, and NSPS Technology--State of Hawaii except for Hilo Coast. These are the same as for Florida and Texas.

BPT, BAT, and NSPS Technology--Puerto Rico. These are the same as for Louisiana.

Costing Methodology. The Economic Analysis Document gives the expected pollution costs for Louisiana and for Puerto Rico for the promulgated BPT and proposed BAT and NSPS regulations. These costs were developed through the use of several model plants. The degree of conformance of each of the existing mills to a model plant was evaluated and costs for upgrading each one were developed separately. Current practices in Florida and Texas and in the portions of Hawaii other than the Hilo Coast are such (irrigation or recycle) that there is already a full compliance with BPT and BAT requirements. Therefore there are no costs involved in these regions. Since the regulations for the Hilo Coast of Hawaii are in suspense, no costs have been calculated for this region.

No limitations have been proposed for pretreatment before discharge to municipal sewage systems. No sugar mills are now known to be discharging to municipal sewers.

Beet Sugar Processing

Production Characteristics and Capacities. The plant size ranges for beet sugar processing are classified according to production capacity, small (less than 2,100 metric tons or 2,300 short tons per day), medium (2,100-3,500 metric tons or 2,300-3,900 short tons per day), and large (greater than 3,500 metric tons or 3,900 short tons per day).

Typical plant production is estimated to be 3,200 metric tons (3,600 short tons) of sliced beets per day. The main products from this industry are refined sugar, dried beet pulp (used for animal feed), and molasses.

The beet sugar processing industry is a subcategory of the sugar processing industry. Water is commonly used for six principal purposes: (1) transporting (fluming) of beets to the processing operation, (2) washing beets, (3) processing (extraction of sugar from the beets), (4) transporting beet pulp and lime mud cake waste, (5) condensing vapors from evaporators and crystallization pans, and (6) cooling.

Beets are transported into the plant by water flowing in a narrow channel (flume) that removes adhered soil. The beets are then lifted from the flume and spray washed. Flume water accounts for about 50 percent of the total plant water consumption.

Process water is associated with the operations of extracting sugar from the beets. Diffusers draw the raw juice from the beets into a solution which contains 10-15 percent sugar. Exhausted beet pulp is later pressed to remove moisture. This exhausted pulp water is usually recycled back to the diffuser.

Lime mud cake waste results when lime is added to the raw juice and the solution is purged with carbon dioxide gas, causing calcium carbonate to precipitate. The sludge formed removes impurities which are suspended in the juice.

Water from barometric condensers is employed in the operation of pan evaporators and crystallizers in the industry. Water is used in large quantities. Condenser water is usually cooled by some device and recycled for use in the plant.

In addition to the above, about 40 percent of the plants employ the Steffen process to recover additional sugar. In the Steffen process, syrup remaining from the above processes is concentrated to form molasses, which is then desugared to recover the sugar. In this step, water is used to dilute the molasses and calcium oxide is added to the solution, causing a precipitate to form. The precipitation process produces the Steffen filtrate and recovered sugar; the filtrate may be directly discharged as a waste or it may be mixed with beet pulp to produce by-products.

Areas of future growth of beet sugar production are expected to be along the Red River between northern Minnesota and North Dakota, and in the Columbia River Basin.

Pollutants and Sources. The major waste sources stem from the primary production processes. These include: (1) beet transporting and washing, (2) processing (extraction of sugar from the beets), (3) carbonating of raw juice, and (4) Steffen processing (for those plants involved in desugaring of molasses). Barometric condensers are also a wastewater source. The primary wastewaters resulting from the beet sugar processing industry are: flume water, lime mud cake from the carbonation process, barometric condenser water, and Steffen process water used to dilute molasses for desugarization.

The basic parameters used in establishing water effluent guidelines to meet BPT are: BOD_5, total suspended solids, pH, and temperature.

Control Technology. Current pollution control technology does not provide a single operation that is completely applicable under all circumstances. The major disposal methods are: reuse of wastes, coagulation, waste retention ponds or lagooning, and irrigation.

BPT and BAT involve extensive recycle and reuse of wastewaters within the processing operations with no discharge or controlled discharge of process wastewater pollutants to navigable waters.

BAT permits no discharge of wastewaters. One method of accomplishing this is to apply the wastewaters to the land after BPT steps have been taken. It is possible that after sufficient concentration of wastewaters, only salt-tolerant grasses could be grown. Farm lands may be taken out of production and no credit is taken for the value of crops grown on these lands. It is uncertain how long the soil can remain stable under these conditions.

Control Costs--Sugar Processing

The combined control costs for cane sugar refining, raw sugarcane processing, and beet sugar processing are summarized in Table W8.2.1.

Table W8.2.1. Sugar processing

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.214E+09 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	2.84	31.97	2.84	11.36	19.35
BAT	6.43	0.0	19.29	25.72	12.86
NEW PLANTS (NSPS)	7.39	15.66	21.49	43.01	67.34
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	16.66	47.63	43.62	80.09	99.55
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	4.58	12.83	12.98	28.95	54.19
BAT	2.54	0.0	5.07	15.22	32.98
NEW PLANTS (NSPS)	4.89	3.87	11.77	32.29	88.69
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	12.00	16.70	29.82	76.45	175.85
O + M					
EXISTING PLANTS					
BPT	3.49	8.63	10.46	21.96	44.10
BAT	0.99	0.0	1.98	5.94	12.88
NEW PLANTS (NSPS)	5.53	4.38	13.31	36.22	89.09
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10.00	13.01	25.76	64.12	146.06
ANNUAL CAPITAL + O+M	22.00	29.71	55.58	140.57	321.91
ALL ANNUAL COSTS	22.00	29.71	55.58	140.57	321.91

Chapter W8.3 Canned and Preserved Fruits and Vegetables

Regulations

The canned and preserved fruits and vegetables processing industry is subject to BPT, NSPS, PSES, PSNS, and BCT regulations described in the Code of Federal Regulations Title 40, Part 407, and as updated in the Federal Register (47 FR 49175, 10/29/82).

The regulations causing significant costs are BPT and NSPS. Point source discharge limitations are defined for the discharge of process wastewater pollutants. Existing BCT regulations, when they exist, equal BPT limitations for all subparts. Existing and new dischargers to POTW's meet no special standards, but must conform to general pretreatment standards provided in 40 CFR, Part 403. In some instances new dischargers to POTW's must reduce incompatible pollutant levels to those designated under NSPS standards.

Industry Characteristics

The fruits and vegetables processing industry includes processors of canned fruits and vegetables, preserves, jams, jellies, dried and dehydrated fruits and vegetables, frozen fruits and vegetables; fruit and vegetable juices, and specialty items. The effluent limitations guidelines issued by the EPA are limited to processors of apple products (except caustic peeled and dehydrated products), citrus products (except pectin and pharmaceutical products), frozen and dehydrated potato products, and specialty fruits and vegetables. The principal items in each group are as follows:

- Apples: slices, sauce, and juice (cider)
- Citrus: juice, segments, oil, dried peel, and molasses
- Potatoes: chips, frozen products, dehydrated products, canned hash, stew, and soup products.
- Specialty fruits and vegetables.

The manufacturing processes employed after harvesting depend on the particular product to be manufactured. Specific processes include receiving, storing, washing and sorting, peeling and coring, sorting, slicing, segmenting or dicing, pressing or extracting (for juice products), cooking, finishing, blanching (for potatoes), juice concentrating, dehydrating, canning, freezing, can rinsing and cooling, and cleaning up. Many processes previously performed by hand, such as peeling and coring, have been automated. Peeling, for example, may be performed mechanically or caustically. In the caustic process the fruit or vegetable is dipped in a hot lye solution to loosen and soften the peel, which is then removed by brushes and water spray.

The fruits and vegetables canning and freezing industry comprises approximately 1,680 plants that are subdivided into 1,038 canned fruits and vegetables plants plus 642 frozen fruits, vegetables, and specialties plants. These plants are further subdivided into canning plants, freezing plants, combination canning and freezing plants, and dehydrating plants. According to the 1982 U.S. Industrial Outlook, shipments of canned and frozen fruits and vegetables reached $13 billion in 1981, an increase of 10 percent over 1980. Approximately 70 percent of all these plants are multiproduct producers, although an equivalent percentage confine their operations to either fruits or vegetables.

The canning and freezing industry is characterized by a large number of small, single-plant firms. These firms share a very small segment of the total market and have very little influence on industry prices and total supply. Over the past 20 years, there has been a steady trend in the industry to fewer large plants from many smaller operations. The four largest firms in the canning, freezing, and dehydrating industries account for approximately 20, 25, and 35 percent, respectively, of the total value of industry shipments. Although a large proportion of the plants are relatively old, the industry has generally maintained modern technology through renovation and equipment modernization.

It is likely that the trend toward fewer plants will continue. New large plants will probably continue to replace the production capacity of the small, older plants that will close.

Pollutants and Sources

Water is used extensively in all phases of the food processing industry; it is used as:

- A cleaning agent to remove dirt and foreign material
- A heat-transfer medium for heating and cooling
- A solvent for removal of undesirable ingredients from the product
- A carrier for the incorporation of additives into the product
- A vehicle for transporting and hauling the product.

Although the steps used in processing the various commodities display a general similarity, there are variations in the equipment used and in the amount and character of the wastewaters produced. For example, caustic peeling produces a much higher pollution load than does mechanical peeling. Similarly, water transport adds a great deal to a plant's wastewater flow compared to dry transportation methods.

The pollutant parameters that have been designated by EPA as being of major significance for apple, citrus, and potato processors are BOD, suspended solids, and pH. Minor pollutant parameters include COD, total dissolved solids, ammonia and other nitrogen forms, phosphorus, fecal coliforms, and heat.

Control Technologies

Control technologies applicable to wastewaters from the fruit and vegetable processing industry consist of both in-plant (or in-process) technologies and conventional end-of-pipe waste treatment technologies. In-plant control methods include field washing of crops; substitution of dry transport methods for flumes; replacing conventional hot water and steam blanching methods by fluidized bed, microwave, hot gas, or individual quick blanching methods; using high-pressure nozzles and automatic shutoff valves on hoses; reusing process waters in countercurrent flow systems, recirculating of cooling waters, etc.; and minimizing the use of water and detergents in plant cleanup.

End-of-pipe treatment technologies used in the fruits and vegetables processing industry generally include preliminary screening, equalization, the use of catch basins for grease removal, sedimentation and clarification, followed by a biological treatment system such as activated sludge and the use of trickling filters, anaerobic lagoons, or aerated lagoons. Where necessary, neutralization and chlorination are also included. Other technologies that are or may be used by the industry include solids removal by air flotation or centrifugal separation, chemical coagulation and precipitation, biological treatment (through the use of a rotating biological contractor), sand or diatomaceous earth filtration, and other advanced treatment technologies. The liquid portion of cannery wastes can be "completely" treated and discharged through percolation and evaporation lagoons or by spray irrigation.

Because the wastes from fruit and vegetable processing plants are primarily biological, they are compatible with municipal sewage treatment systems. Therefore, discharge into municipal systems is also a practicable alternative for fruit and vegetable processors.

BPT guidelines are based upon the average performances of exemplary biological treatment systems. Thus, the technology includes preliminary screening, primary settling (potatoes only), and biological secondary treatment. The use of cooling towers for the recirculation of cooling water is considered a BPT for the citrus industry. In-plant control methods should include good housekeeping and water use practices. No special in-plant modifications are required. Land treatment methods such as spray irrigation are, of course, not excluded from use.

NSPS guidelines assume the use of BPT, plus additional secondary treatment, such as more aerated lagoons and/or shallow lagoons and/or a sand filter following secondary treatment; disinfection (usually chlorination) is also included. Management controls over housekeeping and water use practices are assumed to be stricter than BPT. Although no additional in-plant controls are required, several modifications may be economically more attractive than additional treatment facilities. These include: recycling raw material wash water, utilizing low water-usage peeling equipment, recirculating of cooling water, and utilizing dry clean-up methods. Where suitable land is available, land treatment is not only recommended from the discharge viewpoint, but will usually be more economical than other treatment methods.

Costing Methodology

Model plants were used to estimate the regulatory costs in the canned and preserved fruits and vegetables industry. These model plants for each subcategory were derived in the Economic Analysis and the NCWQ Report. Control costs are summarized in Table W8.3.1.

Table W8.3.1. Canned and preserved fruits and vegetables

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP): .0	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	855.95	0.0	0.0	227.98
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	4.21	25.22	12.22	22.60	42.09
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	4.21	881.17	12.22	22.60	270.06
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	112.54	358.76	337.61	675.21	1112.06
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	4.92	10.75	13.12	30.78	69.52
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	117.46	369.51	350.73	705.99	1181.58
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	1028.75	3277.47	3088.55	6170.95	10270.96
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	1.78	3.16	4.59	11.25	27.05
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	1030.53	3280.63	3093.14	6182.20	10298.00
ANNUAL CAPITAL + O+M	1147.99	3650.14	3443.87	6888.19	11479.58
ALL ANNUAL COSTS	1147.99	3650.14	3443.87	6888.19	11479.58

Chapter W8.4 Canned and Preserved Seafood

Regulations

The canned and preserved seafood processing industry is subject to BPT, NSPS, PSES, PSNS, and BCT regulations described in the Code of Federal Regulations Title 40, Part 408, and as updated in the Federal Register (47 FR 49175, 10/29/82).

The regulations causing significant costs are BPT and NSPS. Point source discharge limitations are defined for the discharge of process wastewater pollutants. Existing BCT regulations equal BPT limitations for all except the following subparts where BCT limitations exceed BPT limitations: Y - Pacific Coast Hand-Shucked Oyster Processing, Z - Atlantic and Gulf Coast Hand-Shucked Oyster Processing, AD - Non-Alaskan Scallop Processing, and AG - Abalone Processing. Existing and new dischargers to POTW's meet no special standards, but must conform to general pretreatment standards provided in 40 CFR, Part 403.

Industry Characteristics

There are approximately 1,800 seafood processors located in the United States, including tuna processing plants located in Puerto Rico and American Samoa. For the purpose of establishing effluent limitations guidelines, the seafood processing industry has been divided into 33 subcategories, as listed in Table W8.4.1. Of these, 14 are in Phase I and 19 are in Phase II. The groupings are based upon the type of product, the degree of mechanization, and the location or remoteness of the processing plant. Remote Alaskan plants have been placed in a separate subcategory because their isolated locations render most wastewater treatment alternatives infeasible because of the high cost of overcoming engineering obstacles and the undependability of access to transportation during extended severe sea or weather conditions.

In general, the seafood processing industry can be characterized as possessing many small, underutilized, old plants that in some cases compete with efficient, low-cost foreign producers. On the other hand, the tuna industry is dominated by five firms that operate 14 large-scale plants which account for over 90 percent of the industry production.

Processing seafood involves variations of a common sequence of operations: harvest, storage, receiving, preprocessing (washing, thawing, etc.), evisceration, precooking, picking or cleaning, preservation, and packaging. Many of the operations, such as picking, shelling, and cleaning, have been mechanized, but much of the industry still depends on conventional hand operations.

In general, the volume of production is dependent upon the amount of seafood harvested, both domestic and imported. Analyses by the U.S.

TABLE W8.4.1 SEAFOOD PROCESSING INDUSTRY SUBCATEGORIES

Phase I

(1) Farm-raised Catfish
(2) Conventional Blue Crab
(3) Mechanized Blue Crab
(4) Non-Remote Alaskan Crab Meat
(5) Remote Alaskan Crab Meat
(6) Non-Remote Alaskan Whole Crab and Crab Section
(7) Remote Alaskan Whole Crab and Crab Section
(8) Dungeness and Tanner Crab Processing in the Contigous States
(9) Non-Remote Alaskan Shrimp
(10) Remote Alaskan Shrimp
(11) Northern Shrimp in the Contiguous States
(12) Southern Non-Breaded Shrimp Processing in the Contiguous States
(13) Breaded Shrimp Processing in the Contiguous States
(14) Tuna

Phase II

(1) Fish Meal
(2) Alaska Hand-Butchered Salmon
(3) Alaska Mechanized Salmon
(4) West Coast Hand-Butchered Salmon
(5) West Coast Mechanized Salmon
(6) Alaskan Bottom Fish
(7) Non-Alaskan Conventional Bottom Fish
(8) Non-Alaskan Mechanized Bottom Fish
(9) Hand Shucked Clam
(10) Mechanized Clam
(11) Pacific Coast Hand-Shucked Oyster
(12) Atlantic and Gulf Coast Hand-Shucked Oyster
(13) Steamed and Canned Oyster
(14) Sardine Processing
(15) Alaskan Scallop Processing
(16) Non-Alaskan Scallop Processing
(17) Alaskan Herring Fillet
(18) Non-Alaskan Herring Fillet
(19) Abalone Processing

National Marine Fisheries Service indicate that a 3.1 percent annual compound growth rate can be sustained through 1985 by the extension of the U.S. fisheries jurisdiction to 200 miles, raising additional fish by aquaculture, and by encouraging the catch and sale of presently underutilized fish species. A fully operational predictive model to forecast the effect of the 200-mile limit is not yet available.

The effluent limitations guidelines issued for the seafood processing industry by the EPA cover all methods of preservation--fresh-pack, freezing, canning, and curing.

Pollutants and Sources

Pollution sources in the seafood processing industry include both the fishing boats (mostly their discharged bilge water) and the processing plants themselves. Water uses in the processing plants include: washing the seafood, plants, and equipment; flumes for in-plant transport of product and wastes; live holding tanks; cooling and ice making; cooking; freezing; and brining.

The solids and effluents from all fish and shellfish operations consist of:

- Solid portions consisting of flesh, shell, bone, cartilage, and viscera
- Hot and cold water (fresh or seawater) solutions containing dissolved materials (proteins and breakdown products)
- Suspended solids consisting of bone, shell, or flesh
- Foreign material carried into the plant with the raw material.

Phase I Subcategories. The major wastes from Phase I seafood processing include blood, viscera, bits of flesh and other tissues, scales, slime and cooking liquors. Wastewaters from processing contain heavy loads of dissolved and suspended fats and proteins. Parameters under effluent guidelines for meeting BPT and BCT include (1) five-day biochemical oxygen demand (BOD_5), (2) total suspended solids, (3) oil and grease, and (4) pH (Table W8.4.2).

Industrial Fishes. There are three primary sources of wastewater in processing of menhaden and anchovies: (1) the bailwater used to transport the fish from the boats, (2) the stickwater, which separates from the oil after the pressing operation, and (3) washwater from refining of the fish oil. Stickwater, a mixture of dissolved and suspended proteins, fats, oil and ash, contributes the heaviest wasteload. In factories equipped with a solubles plant, the stickwater and other wastewaters are evaporated to yield protein concentrate. The barometric condensor of the evaporator produces large volumes of low-strength wastewater. Factories without solubles plants dispose of stickwater by barging to sea. Bailwater, which is commonly recycled, carries a high load of BOD and suspended solids.

TABLE W8.4.2. SEAFOOD INDUSTRY RAW WASTE CHARACTERISTICS

Subcategory	Flow l/kkg	kg/kkg			mg/l		
		BOD_5	TSS	O&G	BOD_5	TSS	O&G
Phase I							
Catfish (farm)	23,000	7.9	9.2	4.5	343.4	400.0	195.6
Crabs							
(Blue conventional)	1,190	5.2	0.74	0.26	4,369.7	621.8	218.4
(Blue Mech.)	36,800	22	12	5.6	597.8	326.0	152.1
(Alaska) NR/R	51,700	66	54	18	1,276.5	1,044.4	348.1
(Dungeness/Tanner)	19,600	8.1	2.7	--	413.2	137.7	--
Shrimp							
(Alaska) NR/R	73,400	130	210	17	1,771.1	2,861.1	231.6
(West Coast)(a)	60,000	120	54	42	2,000.0	900.0	700.0
(Gulf, breaded)	116,000	84	93	--	724.1	801.7	--
Tuna	18,300	13	10	5.8	710.3	546.4	316.9
Phase II							
Fish Meal							
(W solubles)	35,000	2.96	0.920	0.562	84.5	26.2	16
(W/O solubles)	1,900	62.2	34.8	22.8	32,737	18,315	12,000
Sardines	3,640	10.1	2.93	1.99	2,747	804.9	546.7
Herring							
(Filleting)	8,090	32.0	22.6	6.11	3,955	2,793	755.2
Salmon							
(Hand-butchered)	3,960	2.11	1.21	0.153	532.8	305.5	38.6
(Mechanical)	18,500	50.8	20.3	6.49	2,746	1,097	350.8
West/Alaska (composite)	13,300	33.3	13.4	4.21	2,501	1,008	317.
Bottom Fish							
Alaska	6,230	2.00	1.61	0.084	321	258.4	13.4
Non Alaska-Conv.	5,240	3.32	1.42	0.348	633.5	270.9	66.4
Non Alaska-Mach.	13,500	11.9	8.92	2.48	881.4	660.7	183.7
Clams							
(Conventional)	3,700	5.71	13.6	0.141	1,543	3,676	38.1
(Mechanized)	21,100	13.7	5.48	0.444	649.3	259.7	21.0
Oysters							
Steamed or canned	65,100	31.0	29.0	1.13	476.2	445.5	17.3
Hand-shucked (West)	55,300	23.9	34.2	1.55	432.2	618.4	28.0
Hand-shucked (East)	32,600	14.9	13.6	0.665	457.1	417.2	20.4
Scallops							
(Alaska)	11,700	2.85	0.526	0.158	243.6	45.0	13.5
(N. Alaska)	11,700	2.85	0.526	0.158	243.6	45.0	13.5
Abalone	35,700	17.1	8.37	0.897	479.0	234.5	25.1

Finfish. The primary source of wastewater from the processing of salmon is the wash tank operation, where eviscerated fish are cleansed of blood, loose tissues and flesh particles. Mechanical processors produce much heavier wasteloads than manual operations. The same is true for the mechanical processing of bottom fish, such as whiting. Skinning and scaling may produce high waste loads in the conventional processings of bottom fish. For very large bottom fish, i.e., halibut, the primary wastewater flow and wasteload may result from washing the gut cavity. In sardine processing the principal wasteloads are contributed by the precook stickwater and the flume to the packing tables. For the herring filleting industry the largest percentage of flow and wasteload is produced by the filleting machine and associated fluming, with a lesser contribution from the bailwater.

Municipal dischargers comprise a small fraction of the total plants in the industry. Alaskan plants are in an especially difficult position with respect to this option.

According to the EPA Development Documents, the sludge volumes from treatment of seafood wastes, although not demonstrated on a significant scale, are up to 10 percent of raw waste volume from dissolved air flotation, 10 to 15 percent from activated sludge, 5 to 10 percent from extended aeration and 2 percent from anaerobic contact processes. These sludges have a high water content (95-98 percent) and are amenable to conventional sludge handling except for sludge from air flotation which may be difficult to dewater.

Waste waters from the seafoods industry contain compatible pollutants. There is no evidence that toxic pollutants as defined in the EPA toxic pollutant effluent standards are present in the wastewaters from any subcategory.

Control Technologies

Control technologies applicable to the seafood processing industry include both in-plant changes and end-of-pipe treatment. Basic in-plant changes include:

- Minimizing the use of water by substituting dry handling for flumes, using spring-loaded hose nozzles, etc.
- Recovering dissolved proteins by precipitation from effluent streams, enzymatic hydrolysis, brine-acid extraction, or through the conventional reduction process for converting whole fish or fish waste to fish meal.
- Recovering solid portions for use as edible product or as by-products by mechanical deboning and extruding, and by shellfish waste utilization.

Very few end-of-pipe waste treatment systems are currently installed in the seafood processing industry. However, the essentially biodegradable nature of the wastes allows for the easy application of conventional treatment methods. These include screening and sedimentation to remove suspended solids; air flotation and skimming to remove heavy concentrations of solids, greases, oils, and dissolved organics; biological treatment systems, such as activated sludge, rotating biological contractors, trickling filters, ponds, and lagoons to remove organic wastes; and land disposal methods where land is available.

In general, BPT guidelines call for in-plant "good housekeeping" practices, but do not assume significant equipment changes. End-of-pipe technologies associated with BPT are represented by simple screening and grease-trap methods, with dissolved air flotation for tuna plants and grinders or comminutors, followed by discharge to deep water for remote Alaskan processors where adequate flushing is available. NSPS guidelines place much more emphasis on in-plant changes, including in-process modifications which promote efficient water and wastewater management to reduce water consumption, recycling some water streams, and solids or by-product recovery where practicable. End-of-pipe technologies associated with NSPS guidelines include more extensive use of dissolved air flotation, for tuna processors in 1983.

Costing Methodology

Model plants were used to estimate this regulatory cost in the canned and preserved seafood industry. These model plants for each subcategory were derived from Development Documents and the NCWQ Report. Control costs are summarized in Table W8.4.3.

Table W8.4.3. Canned and preserved seafood

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	48.78	0.0	0.0	6.28
BAT	2.48	0.0	7.45	9.93	4.96
NEW PLANTS (NSPS)	2.87	13.78	8.28	17.63	38.42
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	5.35	62.56	15.72	27.56	49.66
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	6.41	15.92	19.24	38.48	63.97
BAT	0.98	0.0	1.96	5.87	12.73
NEW PLANTS (NSPS)	2.90	5.57	7.58	18.71	48.47
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	10.29	21.49	28.78	63.06	125.16
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	4.55	11.54	13.72	27.18	44.31
BAT	0.09	0.0	0.17	0.52	1.13
NEW PLANTS (NSPS)	3.45	6.64	9.02	22.25	58.04
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	8.08	18.18	22.92	49.95	103.48
ANNUAL CAPITAL + O+M	18.37	39.67	51.70	113.01	228.64
ALL ANNUAL COSTS	18.37	39.67	51.70	113.01	228.64

Chapter W8.5 Dairy Products Processing Industry

Regulations

Regulations which were published as of February 11, 1975 are the basis for this chapter. Since publication BAT has been redesignated BCT, and in 1981, BCT requirements were remanded. Therefore, only compliance costs for BPT and NSPS regulations are presented in this chapter.

Industry Characteristics

In 1970, there were 5,241 dairy plants reported in the United States, and by 1977, the number of plants had dropped to 3,731 plants, a 29 percent decline. The size of each plant is determined by the number of employees required, where a small operation has 1-19 employees, a medium one has 20-99 employees, and a large plant over 100 employees.

The dairy processing industry comprises 12 product-related subcategories: (1) receiving stations, (2) fluid products, (3) cultured products, (4) cottage cheese, (5) butter, (6) natural cheese, (7) ice cream, (8) ice cream mix, (9) condensed milk, (10) dry milk, (11) condensed whey, and (12) dry whey.

A great variety of operations are employed in the dairy products industry. For simplification, they are considered to be a chain of operations involving: (1) receiving and storing, (2) clarifying, (3) separating, (4) pasteurizing, and (5) packaging.

Receiving and storing of raw materials is conducted by using bulk carriers, pumps, and refrigerated tanks. Clarifying is the removal of suspended matter by centrifuging. Separating is the removal of cream by centrifuging. Pasteurizing is accomplished by passing the material through a unit where it is rapidly heated then cooled by contact with heated and cooled plates or tubes. Packaging involves the final handling of the finished product prior to storage.

Pollutants and Sources

Materials are lost during direct processing of raw materials into finished products and from ancillary operations. The former group consists of milk, milk products, and nondairy ingredients (sugar, fruits, nuts, etc.), while the latter consists of cleaners and sanitizers used in cleaning equipment and lubricants used in certain handling equipment. All of these contribute to the release of organic materials, which appear as high BOD and suspended solids in the process water. Phosphorus, nitrogen, chlorides, heat, and dairy fat can also be found.

The major sources of wastes in the dairy products processing industry are the following: (1) the washing and cleaning out of product remaining in tanks and piping which is performed routinely after every processing cycle, (2) the spillage produced by leaks, overflow, freezing-on, boiling-over and careless handling, (3) processing losses, (4) the wastage of spoiled products, returned products, or by-products such as whey, and (5) the detergents used in the washing and sanitizing solutions.

The primary waste materials that are discharged to the waste streams in practically all dairy plants include: (1) milk and milk products received as raw materials, (2) milk products handled in the process and end-products manufacture, (3) lubricants (primarily soap and silicone-based) used in certain handling equipment, and (4) sanitary and domestic sewage from toilets, washrooms, and kitchens. Other products, such as nondairy ingredients (sugar, fruits, flavors, and fruit juices) and milk by-products (whey and buttermilk) are potential waste contributors.

Control Technology and Costs

Dairy wastes are usually subjected to biological breakdown. The standard practice for reducing the concentration of oxygen-demanding materials in the wastewater has been to use secondary or biological treatment consisting of: activated sludge, trickling filters, aerated lagoons, stabilization ponds, or land disposal. Tertiary treatment (sand filtration, carbon adsorption) is practically nonexistent at the present time.

BPT consist of in-plant and end-of-pipe controls. In-plant control includes improvement of plant maintenance, waste monitoring equipment and quality control improvements.

End-of-pipe control includes biological treatment (activated sludge, trickling filters, or aerated lagoons). If in-house controls are not used, end-of-pipe biological treatment must be supplemented by rapid sand filtration. Small dairies may be able to meet BPT through land disposal options.

Based on the Development and Economic Analysis documents, the industry was modeled in terms of small, medium, and large plants in five product sectors: (1) butter, (2) milk and cottage cheese, (3) processed cheese, (4) ice cream, and (5) condensed evaporated milk. Treatment technologies, costs, and estimates of existing compliance levels were also obtained from the same documents. The estimated costs of compliance are given in Table W8.5.1.

Table W8.5.1. Dairy products processing industry

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.339E+09				
	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	199.32	0.0	0.0	66.28
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	11.64	44.59	33.35	70.02	148.59
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	11.64	243.91	33.35	70.02	214.87
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	26.21	92.38	78.62	157.23	254.44
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	10.25	16.81	26.22	66.56	179.36
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	36.45	109.19	104.84	223.80	433.80
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	3.88	14.99	11.88	23.14	36.64
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	3.47	5.70	8.86	22.48	60.44
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	7.34	20.69	20.76	45.63	97.07
ANNUAL CAPITAL + O+M	43.80	129.89	125.60	269.42	530.88
ALL ANNUAL COSTS	43.80	129.89	125.60	269.42	530.88

Chapter W8.6 Feedlots Industry

Regulations

The feedlots point source category is comprised of two subcategories for which BPT, BAT (old), NSPS and pretreatment have been adopted. These standards are applicable only to large scale feedlot operations.

Industry Characteristics

Feedlots is a term which applies to many different types of facilities used to raise animals in a "high density" situation. For the purpose of establishing effluent limitations guidelines, the term feedlots has been defined by the following three conditions:

- There is a high concentration of animals held in a small area for periods of time in conjunction with the production of meat, milk, eggs, and/or breeding stock; and/or the stabling of horses;
- There is transportation of feed from other areas to the animals for consumption and;
- By virtue of the confinement of animals or poultry, the land or area will neither sustain vegetation nor be available for crop or forage production.

The effluent limitations guidelines issued to date (Phase I) by the EPA cover feedlots for beef cattle, dairy cattle, swine, chickens, turkeys, sheep, ducks, and horses. A variety of facility types are included within the definition of feedlots. These include: open lots, housed lots, barns with stalls, free-stall barns, slotted-floor houses, solid concrete floor houses, a variety of poultry houses, and wet lots containing swimming areas for ducks.

Raw materials used in the feedlots industry are feed, water, and in some cases, bedding. The production processes are defined by the type of facilities employed, and consist mostly of delivering supplies to the animals and carrying away manure and litter.

Although most of the feedlots are classified as small, for many animals the bulk of production is accounted for by the very large producers. Although this concentration is not so dominant in some of the other animal groups, the trend toward larger units of production is common to all segments of the industry.

Many producers have diversified into grain production for direct marketing and production of other livestock and poultry. Some are involved in feed grain producing, feed-manufacturing, feeder-cattle producing, and/or meat packaging.

Ownership of commercial feedlots ranges from sole-proprietorships to corporate farms, including co-operatives. The feedlot operator may own the animals being fed or, (particularly in the case of fed-cattle) may custom-feed animals owned by others.

Projections of production capacity through 1983 for the cattle, dairy, and hog segments of the feedlots industry anticipate that the trend is toward fewer numbers of production units with the very large units continuing to increase their output volume. Similar projections are not available for the remaining segments of the feedlots industry. However, the growth of production of major agricultural commodities for the period 1970-85 has been estimated. The percentage changes are as follows: beef and veal (33 percent); pork (13 percent); milk (2 percent); chicken (36 percent); turkey (44 percent); eggs (10 percent); and lamb and mutton (65 percent). In all segments of the feedlots industry, it is anticipated that the trend toward larger feedlots will continue. No substantive growth projections are available for the duck or horse subcategories.

Pollutants and Sources

Feedlot wastewater originates from two principal sources:

- Rainfall runoff
- Flush or washdown water used to clean animal wastes from pens, stalls, milk center areas, houses; runoff from continuous overflow watering systems or similar facilities; spillages; runoff from duck swimming areas; runoff from washing of animals; runoff from dust control; etc.

The amount of wastewater varies considerably, depending upon the way manure, bedding, etc., are stored and handled; in the outdoor feedlots, rainfall and soil characteristics determine wastewater characteristics.

Animal Feedlot wastes generally include the following pollutants:

- Bedding or litter (if used) and animal hair or feathers
- Watering- and milling-center wastes
- Spilled feed
- Undigested and partially digested food or feed additives
- Digestive juices
- Biological products of metabolism
- Micro-organisms from the digestive tract
- Cells and cell debris from the digestive tract
- Residual soil and sand.

The primary discharge constituents of concern for pollution control can be described as organic soils, nutrients, salts, and bacterial contaminants. The following specific pollutant parameters have been identified as being of particular importance: BOD_5, COD, fecal coliform, total suspended solids, phosphorus, ammonia and other nitrogen forms, and dissolved solids.

With the exception of the duck feedlot subcategory, the EPA has concluded that animal feedlots can achieve a BPT level of waste control which prevents the discharge of any wastes into waterways, except for overflows due to excessive rainfall or similar unusual climatic events (a 10-year, 24-hour storm as defined by the National Weather Service). The effluent limitations for discharges from duck feedlots have been set at 0.9 kilogram (2 pounds) of BOD_5 per day for every 1,000 ducks being fed, and a total viable coliform count less than that recommended by the National Technical Advisory Committee for shellfish-producing waters, which is 400 fecal coliform per 100 milliliters. The effluent limitations guidelines for all subcategories effective July 1, 1984 (BAT), and for all new sources (NSPS) are no discharge of wastewater pollutants, except for overflows due to rainfalls in excess of the 25-year, 24-hour storm (as defined by the National Weather Service).

Control Technology

In-process technologies used for the control of wastewaters from animal feedlots include: site selection, selection of production methods, water utilization practices, feed formulation and utilization, bedding and litter utilization, and housekeeping procedures. All of these are important in minimizing wastewater flow and pollutants.

The various technologies available for end-of-process treatment may be classified as either partial or complete. Partial technologies are defined as those that produce a product or products which are neither sold or completely utilized on the feedlot. Thus, gasification and incineration of manure are considered partial technologies because each generates a significant quantity of ash that must be disposed of. Lagoons, trickling filters, and other biological systems are classified as partial technologies because the effluent may not be suitable for discharge, and, in all cases sludge disposal is necessary. Complete treatment technologies produce a marketable product or a product that can be entirely reused at the feedlot, and which has no appreciable by-products, residues, or polluted water discharge. The dehydration and sale of manure, for example, is a complete technology. Spreading animal wastes on land for crop fertilization is also a complete control technology.

The 1977 BPT guidelines for all animal feedlots (except those for ducks), the 1984 BAT, and the NSPS guidelines all assume the use of complete control technology. The BPT guidelines are based on the containment of all contaminated liquid runoff and the application of these liquids, as well as the generated solid wastes, to productive cropland at a rate which will provide moisture and nutrients that can be utilized by the crops. Technologies applicable to BAT guidelines include some of the complete technologies, such as wastelage (addition of waste products to feed), oxidation ditch mixed liquor refeed, and the recycling of wet-lot water for ducks, which are not yet fully available for general use. The BPT guidelines for duck feedlots require the equivalent of primary settling, aeration, secondary settling, and chlorination prior to discharge.

Costing Methodology

The costs of compliance were estimated using an industry model based on separate costing sectors for each of the regulatory subcategories (beef, ducks, etc). Plant sizes and numbers were derived from data in the Development and Economic Analysis Documents supplemented by other data sources.

Comprehensive and reliable data were not available on the number of feedlots that will require construction of pollution control facilities to meet the effluent limitations guidelines. It is generally accepted that housed (total confinement) and pasture operations can generally meet the guidelines without new investment or operating cost outlays.

Furthermore, open or partially open feedlots may be situated so that they are not point-source dischargers. Finally, some feedlots have already installed control facilities which meet the guidelines' requirements. Control costs were developed from the cost functions of model plants and are summarized in Table W8.6.1.

Table W8.6.1. Feedlots industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .661E+08

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	60.32	0.61	0.61	31.25
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	7.03	35.75	19.89	43.78	107.42
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	7.03	96.07	20.50	44.39	138.67
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	8.01	27.88	23.95	47.99	79.48
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	7.31	14.89	19.23	47.32	125.47
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	15.33	42.76	43.18	95.31	204.95
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	9.26	32.24	27.70	55.50	92.65
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	8.44	17.24	22.20	54.59	145.40
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	17.71	49.48	49.90	110.09	238.04
ANNUAL CAPITAL + O+M	33.03	92.25	93.08	205.40	443.00
ALL ANNUAL COSTS	33.03	92.25	93.08	205.40	443.00

Chapter W8.7 Meat Products Processing

Regulations

The costs discussed in this chapter are associated with the regulations as originally promulgated. BAT regulations for the industry are currently under review by EPA; the costs for compliance with BAT are subject to change if the BAT regulations are modified.

Meat Packing (Phase I)

Industry Characteristics. A total of 90 percent of the industry's production is accounted for by 15 percent of the plants. Although the total number of plants in the Development Document slaughterhouse and packinghouse categories is only 793, it was assumed that these plants produce 90 percent of the output, and that locker plants (very small meat packing plants that slaughter animals and may produce processed meat products which are usually stored in frozen form) account for the remaining 10 percent.

The meat processing industry comprises four subcategories: simple slaughterhouse, complex slaughterhouse, low-processing packinghouse, and high-processing packinghouse. The plants in this industry range from those that carry out only one operation, such as slaughtering, to plants that also carry out commercial meat processing.

Simple slaughterhouses have very limited by-product processing and usually no more than two other operations such as: rendering, paunch and viscera handling, blood processing, or hide processing. Complex slaughterhouses carry out extensive by-product processing with at least three of the aforementioned operations. Low-processing packinghouses process only animals killed at the plant; normally they process less than the total kill. High-processing packinghouses process both animals slaughtered at the site and additional carcasses from outside sources.

Factors serving to restrain potential growth of the American meat packing industry include higher meat prices, removal of import quotas, and the availability of synthetic (soybean protein) substitutes. The trend is for any new plants to be larger and more specialized (such as large beef or pork slaughterhouses) and to be located closer to the animal supply (movement from urban to rural areas).

Pollutants and Sources. Wastewaters from slaughterhouses and packinghouses contain organic matter including grease, suspended solids, and inorganic materials such as phosphates, nitrates, and salt. These materials enter the waste stream as blood, meat and fatty tissue, meat extracts, paunch contents, bedding, manure, hair, dirt, curing and pickling solutions, preservatives, and alkaline detergents.

Water is used in the meat processing industry to cleanse products and to remove unwanted material. The primary operations where wastewater originates are: animal holding pen operations (waste from water troughs, washdown, and liquid wastes), slaughtering (killing, blood processing, viscera handling and offal washing, and hide processing), and clean-up.

The basic parameters used to define waste characteristics are BOD, suspended solids, grease, and ammonia (NSPS and BAT). The total number of municipal dischargers is 70 percent of the number of plants. The average wastewater flows for simple slaughterhouse, complex slaughterhouse, low-process packinghouse, and high-process packinghouse are 1.17, 4.35, 3.41 and 4.54 million liters (0.31, 1.15, 0.90, 1.2 million gallons) respectively per day. About 70-75 percent of the total wastewater volume is discharged to municipal systems.

Control Technology and Costs. Current end-of-pipe treatment for direct dischargers assumes that all plants have in-plant controls for primary treatment, and a secondary treatment system employing anaerobic and aerobic lagoons. Dissolved air flotation is used for primary treatment, either alone or with screens; however, 30 percent of the plants use a catch basin. Since a small percentage of the industry have more advanced secondary treatment systems (such as activated sludge, trickling filters, or spray irrigation) and a small percentage of meat packers have no waste treatment beyond primary treatment, it can be assumed that the typical plant today is characterized by primary treatment plus anaerobic and aerobic lagoons.

Best Practicable Technology consists of end-of-pipe treatment represented by anaerobic-plus-aerated lagoons and aerated lagoons with efficient solid-liquid separation. Disinfection by chlorination is also required. Land disposal, when available, may be an economical option, especially for small plants. End-of-pipe treatment is assumed to be preceded by in-plant controls; these are: reduction of water use through shut-off valves, extensive dry cleaning, use of gravity catch basins, blood recovery, and dry dumping of paunch waste. NSPS are the same as BPT with an additional requirement for control of ammonia.

In addition to BPT, Best Available Technology suggests chemical additions prior to dissolved air flotation, nitrification-denitrification (or ammonia stripping), and sand filtration following secondary treatment.

Meat Products (Phase II) - Red Meat Products

Industry Characteristics. Plants have been classified by size according to the production of finished product. A small processor produces less than 2,720 kilograms (6,000 pounds) per day while a large processor produces in excess of that amount. Large processors are further divided into the following product-mix categories: meat cutter, sausage and luncheon meat processor, ham processor, and canned meat processor.

Production processes for subcategories in this segment of the red meat industry are varied but most often include: receiving and storage; boning and sizing; cooking, preserving, and other preparing of finished products; packaging; and finished product storing and shipping.

Pollutants and Sources. Wastewaters from meat processing plants contain organic matter, suspended solids and inorganic materials, such as phosphates, nitrates, nitrites, and salt. These materials enter the wastestream as meat and fatty tissues, grease, meat juices, product spills, curing and pickling solutions, preservatives, and detergents. In order to define waste characteristics, the following basic parameters were used to develop guidelines for meeting BPT and BAT: five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), oil and grease, and fecal coliforms.

The wastes from the meat products industry contain compatible pollutants. There is no evidence that toxic pollutants as defined in the EPA toxic pollutant effluent standards are present in the wastewaters from any of the meat products industry subcategories.

Control Technology and Costs. Waste treatment practices in the meat processing industry vary widely according to the age, size, and location of plants. Many now use primary treatment (including screening and catch basins) for waste material recovery. Where secondary wastewater treatment is practiced, anaerobic processes are commonly employed, followed by a trickling filter, aerated lagoon, or activated sludge process. BPT guidelines for large plants discharging to waterways call for a major removal of BOD_5, TSS, and grease through installation of primary treatment (screening, equalization, dissolved air flotation) followed by secondary biological treatment, such as activated sludge or extended aeration combined with a facultative lagoon and disinfection. EPA assumed that BPT investment for existing plants was limited to chlorination equipment. BAT guidelines project a further reduction in BOD_5, TSS, and oil and grease by means of filtration. In-plant controls for reduction in wastewater volumes are also assessed. Septic tanks are considered to provide BPT and BAT for small processors.

The Meat Packing (Phase I) and Red Meat Products (Phase II) categories were combined for the estimation of control costs.

Meat Processing (Phase II) - Poultry Processing

Industry Characteristics. The size of a model plant is determined by the number of birds processed per day. Large plants may process in excess of 120,000 birds in a single day.

This segment of the meat products industry has been divided into the following subcategories: Chicken processor, Turkey processor, Fowl processor (mature chickens, geese, and capons), Duck processor, and Further processor (no slaughtering).

The production processes for poultry processing include: receiving birds; killing; bleeding, defeathering including scalding, picking, singeing and washing; eviscerating, including viscera removal, giblet processing, and carcass washing; weighing, grading, packaging, and chilling; and shipping. These steps with minor variations, are used in the processing of chickens, turkeys, fowl, and ducks.

"Further Processing" includes those poultry plants that conduct further processing of poultry products only, but do no on-site slaughter. Further processing of poultry products (chickens, fowl, turkeys, or ducks) includes the following steps: receiving and storage; thawing; cut-up operations; cooking; battering and breading; cooking; freezing and packaging; and cold storing; or alternatively, after receiving and storage, thawing; boning; dicing, grinding, and chopping; mixing and blending; stuffing or canning; cooking; final product preparing; freezing and packaging; and cold storing.

The compound annual growth rate over the period 1973 to 1980 has been estimated at between 4.9 and 5.6 percent.

Pollutants and Sources. Materials are generated through direct processing of raw materials into finished products and from ancillary operations. The former group consists of blood, viscera, fat, and flesh scraps, while the latter consists of cleaners and sanitizers used in cleaning equipment and lubricants used in certain handling equipment. All of these contribute to the release of organic materials, which exert a high BOD and elevate the oil, grease and suspended solids levels in the process water. Phosphorus, nitrogen, and chlorides can also be found.

The most significant single waste source in the poultry products processing industry is blood from the walls of the blood tunnel which is washed into sewers.

The following basic parameters were used to define waste characteristics and to develop guidelines for meeting BPT: BOD_5, total suspended solids, oil and grease, fecal coliforms, and pH. Poultry industry subcategories wastes contain compatible pollutants as defined by EPA Pretreatment Standards, hence pretreatment is not required. Furthermore, no toxic materials as defined in the Toxic Pollutants Effluent Standards are present in wastes from this industry.

Control Technology and Costs. Poultry wastes are usually amenable to biological breakdown. A few plants in various subcategories of this industry are currently meeting the BPT limitations promulgated by EPA. Most plants in all subcategories either discharge to municipal treatment systems or utilize some form of secondary biological treatment. Either a three-lagoon system or an activated sludge system, both followed by chlorination, are suitable alternatives for meeting BPT limitations provided that in-plant grease and solids recovery are practiced. Spray irrigation (land application) is practiced by a few plants. The sale of crops grown on the irrigated acreage can help defray the costs of the land.

To meet BAT limitations, most plants in all subcategories will require, in addition to the BPT requirements, in-plant water conservation practices, dissolved air flotation with pH control and chemical flocculation for oil and grease removal, an ammonia control process, and a final sand filter or microstrainer.

Control costs were estimated for the Poultry Processing category (Phase II).

Meat Products (Phase II) - Renderers

Industry Characteristics. Independent rendering resulting in inedible products is distinguished from on-site rendering (slaughterhouse or packinghouse) producing edible (lard) products.

Independent rendering plants range in size from very small plants having only one to four employees and a value of shipments of about $150,000 to large plants hiring in excess of 100 employees and having annual sales of $12 million. Average size plants, according to EPA, employ 23 persons and have annual sales of about $1.5 million. For purposes of pollution control costing, three plant size are used--1-9 employees, 10-49 employees, and 50 and more employees.

A single product-related subcategory has been deemed adequate to represent the activities and the pollutants of this industry.

The production steps in independent inedible rendering are as follows:

- Raw material recovery
- Crushing and grinding
- Cooling and moisture removal
- Liquid-solid separation
- Grease clarifying, storing, and shipping
- Meal grinding and screening
- Blending
- Meal storing and shipping
- Hide curing.

Variations in the overall rendering process occur depending on whether batch or continuous systems are used.

Pollutants and Sources. Rendering is a process to convert animal products, by heating, into fats, oils, and proteinaceous solids. A variety of waste meat products including fat trimmings, meat scraps, feathers, offal, bone, and whole carcasses are processed continuously or in batches. The raw material is crushed, then cooked under pressure as required. Fats and oils are allowed to drain off, and the solid material remaining is pressed, ground, and screened to prove a protein-bone meal mixture. Tallow and greases are separated. The large amounts of moisture released in cooking are collected by condensation. Plants which process a large number of dead animals may include facilities for hide curing.

The principal operations and processes in rendering plants where wastewater originates are raw material receiving, condensing cooking vapors, plant cleanup, and truck and barrel washing. Wastewaters from rendering plants contain organic matter, suspended solids, and inorganic materials, such as phosphates, nitrates, nitrites, and salt. These materials enter the wastestream as blood, meat and fatty tissues, body fluids, hair, dirt, manure, tallow and grease, meal products, detergents, and hide curing solutions (where used).

The wastes from all subcategories in the meat products industry contain compatible pollutants. There is no evidence that toxic pollutants as defined in the EPA toxic pollutant effluent standards are present in the wastewaters from any of the meat products industry subcategories.

In order to define waste characteristics, the following basic parameters were used to develop guidelines for meeting BPT and BAT: five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), oil and grease, pH, fecal coliform, and ammonia.

Control Technology and Costs. Wastes in the independent rendering industry are amenable to biological treatment. Off-site rendering plants are divided nearly evenly between those which discharge to municipal sewer systems and those which treat their wastes. Of the latter group, half achieve no discharge of pollutants by means of spray irrigation or ponding. The treatment technology is essentially the same as for meat processors. BPT guidelines for plants discharging to waterways call for a major removal of BOD_5, TSS, grease, and fecal coliform bacteria through installation of primary treatment (equalization, screening, dissolved air flotation, and disinfection). Next is secondary biological treatment, such as activated sludge or extended aeration combined with a facultative lagoon and disinfection. BAT criteria call for further reductions in BOD_5, TSS, and grease, to be achieved by sand filtration; ammonia control is also mandated. In-plant controls for reduction in wastewater volume are also assumed. New source performance standards are the same as BPT for existing plants with the addition of ammonia limitations.

Control Costs--Meat Packing Industry

Table W8.7.1 shows combined control costs for all sectors of the Meat Products Processing Industry.

Table W8.7.1. Meat products processing

WATER POLLUTION CONTROL COSTS (IN MILLIONS OF DOLLARS) CAPITAL IN PLACE (KIP):	.117E+09 1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	7.02	39.15	21.05	28.07	20.36
BAT	56.87	0.0	172.85	228.89	112.92
NEW PLANTS (NSPS)	22.20	68.77	60.57	140.95	366.53
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	86.09	107.92	254.47	397.91	499.81
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	7.91	13.58	20.98	47.49	86.66
BAT	22.73	0.0	45.65	135.93	293.57
NEW PLANTS (NSPS)	17.01	25.37	42.53	114.06	358.06
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	47.64	38.95	109.16	297.47	738.29
O + M					
EXISTING PLANTS					
BPT	13.89	38.39	39.04	84.78	175.05
BAT	50.86	0.0	102.53	301.06	628.50
NEW PLANTS (NSPS)	36.22	55.86	91.20	241.27	740.16
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	100.96	94.25	232.77	627.11	1543.71
ANNUAL CAPITAL + O+M	148.61	133.20	341.92	924.58	2282.00
ALL ANNUAL COSTS	148.61	133.20	341.92	924.58	2282.00

Chapter W8.8. Leather Tanning and Finishing Industry

Regulations

Effluent limitations and standards applicable to the leather tanning and finishing industry were proposed in Federal Register, Vol. 44, No. 128, July 2, 1979. As a result of comments received from the industry, EPA reviewed the entire database and all documentation supporting the rulemaking; it also conducted a program to acquire supplemental data during and after the comment period. Regulations were promulgated by EPA in Federal Register, Vol. 47, No. 226, November 23, 1982, which supercede all previously promulgated BPT and BAT limitations and NSPS, PSES and PSNS.

Industry Characteristics

The Leather Tanning and Finishing Industry (SIC 3111) comprises establishments primarily engaged in tanning, currying, and finishing hides and skins into leather. It includes two types of tanneries: regular and contract. The regular tanneries, which account for about 70 percent of the establishments in the industry, process purchased hides for shipment (or sale) to other industries. The contract tanneries, which are generally the smaller plants, process raw materials owned by others on a fee basis. Both types of tanneries generate significant amounts of effluent and are covered by the proposed regulations on effluent guidelines. In addition to the tanneries, the industry also includes a small number (less than ten percent of the industry) of converters, who buy hides and skins for processing by others on a contract basis. These are normally small nonmanufacturing agencies which do not fall within the purview of the regulations.

The 1977 Census of Manufactures indicates that there were a total of 465 establishments in the industry; 315 regular tanneries, 107 contract tanneries, and 43 converters. EPA sponsored surveys of the industry revealed that only 158 of the 422 tanneries (regular and contract) were generating any significant levels of waste water. The remaining establishments classified as tanneries were either small nonmanufacturing agencies or small plants involved in dry-finishing, only.

The 158 tanneries are subcategorized into nine subcategories as listed below. The first seven were identified in the proposed regulations. The eighth and ninth subcategories were established in the recent regulations.

	Subcategory	Number of tanneries
1.	Hair pulp/chrome tan/retan-wet finish	61
2.	Hair save/chrome tan/retan-wet finish	7
3.	Hair save/non-chrome tan/retan-wet finish	13
4.	Retan-wet finish-sides	16
5.	No beamhouse	24
6.	Through-the-blue	13
7.	Shearling	8
8.	Pigskin	2
9.	Retan-wet finish-splits	14
	Total	158

Production in the industry reached a peak in 1965 with total shipments of 33.1 million equivalent units of cattle hide. Since then, production has been declining; although, the level has remained, relatively stable over the past five years. Shipments in 1981 amounted to 19.5 million cattle hides. The value of shipments (in current dollars) in 1980 was $1.0 billion and increased to $2.2 billion in 1981.

Pollutants and Sources

There are three major groups of standard processing steps required to manufacture leather:

1. Beamhouse processes in which hides or skins are washed and soaked and attached hair is removed;
2. Tanyard processes in which the proteinaceous matter in the hides or skins reacts with and is stabilized by the tanning agent, primarily trivalent chromium; and
3. Retanning and wet finishing processes in which further tanning is accomplished by chemical agents; color is imparted by dyes; lubrication is affected by natural and synthetic fats and oils; and related finishing steps are completed to dry the leather, correct surface irregularities, and apply surface coatings.

The leather making processes are highly water dependent. Large quantities of water are used in the leather tanning and finishing industry for the following purposes:

1. For soaking and washing unprocessed hides or skins;
2. As a medium for dissolving chemicals needed for the treatment of hides or skins;
3. As a carrier for dyes and pigments, which impart the desired color to the final product; and
4. For cleaning processing areas and equipment.

As indicated above, water is essential to leathermaking and is used in virtually all leathermaking processes. Various chemical reagents, chemicals, preservatives, biocides, coloring pigments, and solvents are also integral to leathermaking. Characteristics of the wastewater effluents discharged by tanneries vary depending upon the mix of production processes at a given plant. General wastewater constituents, which contribute to numerous problems for POTW and industrial treatment facilities, include large pieces of scrap hide and leather and excessive quantities of hair and other solids that clog or foul operating equipment and cause fluctuations in wastewater flow and pH. The wastewater contains high levels of suspended and settleable solids, biodegradable organic matter, and significant quantities of toxic pollutants.

The most important pollutant or pollutant parameters to the leather tanning and finishing industry are:

1. Toxic pollutants--trivalent chromium, lead, zinc, cyanide, phenol, substituted phenols, dichlorobenzenes, maphthalene, benzene, chloroform, ethylbenzene, and toluene;

2. Conventional pollutants--BOD, TSS, pH, and oil and grease; and

3. Non-conventional pollutants--ammonia, total kjeldahl nitrogen (TKN), sulfide and COD.

These and other chemical constituents contribute to odors, facility corrosion, hazardous gas generation, and problems in treatment plant performance and disposal of sludges containing chromium and other toxic pollutants. Table W8.8.1 lists the major pollutants generated by the leather tanning and finishing industry and the processes which generate them.

Control Technologies

The control technologies costed in this analysis are based on the regulations promulgated in the Federal Register of November 23, 1982. These regulations specify effluent limitations for BPT, BCT, BAT, and NSPS for direct dischargers and PSES and PSNS for indirect dischargers.

BPT. The control technology selected for compliance with BPT effluent limitations is extended aeration activated sludge biological treatment, including coagulation-sedimentation with equalization.

The pollutant parameters regulated by BPT are BOD, TSS, oil and grease, total chromium and pH.

BAT. Equals BPT.

NSPS. The control technology required for compliance with New Source Performance Standards (NSPS) is the same as that for BAT (BPT) described above. The pollutants controlled are also the same as those for BPT listed above.

Table W8.8.1. Major pollutants generated by the leather tanning and finishing processes

Major pollutant or pollutant parameter	Processing step	Comments
Phenol	1. Storage of hides and skins	1. Biocides containing phenol are used to retard bacterial action and lengthen storage time.
	2. Pickling	2. Sometimes small amounts of biocides are added during this processing step.
	3. Non-chrome tanning	3. Synthetic tanning agents and natural tanning agents contain phenol.
	4. Coloring	4. Dyestuffs containing phenol are used to color leather
	5. Fatliquoring	5. Biocides are added during this processing step.
Chromium	1. Chrome tanning 2. Retanning	1. Chromium compounds are used extensively throughout the leather tanning industry. Chromium is the most prevalent toxic pollutant found in wastewaters of this industry. Almost all compounds are used in the trivalent form. Use of the hexavalent chromium in the "two bath" tanning process is nearly obsolete. Trivalent chromium is the predominant tanning agent used.
BOD	1. Soak and wash	1. Derived from extraneous hide substances such as dirt, blood, and manure.
	2. Unhairing	2. Derived from dissolved or "pulped" hair.
	3. Bating	3. From ammonia which is derived from residual bating chemicals and from hydrolytic deamination of proteinaceous hair and hide substances.

continued.....

Table W8.8.1. (Continued)

Major pollutant or pollutant parameter	Processing step	Comments
COD	1. Soak and wash	1. Derived from extraneous hide substances such as dirt, blood, and manure.
	2. Unhairing	2. Complex organic and inorganic process chemicals.
	3. Bating	3. Complex organic and inorganic process chemicals.
	4. Pickling	4. Complex organic and inorganic process chemicals.
	5. Chrome tanning	5. Complex organic and inorganic process chemicals.
	6. Retanning	6. Complex organic and inorganic process chemicals.
	7. Non-chrome tanning	7. Vegetable tannins
	8. Coloring	8. Dyes
Oil & Grease	1. Degreasing	1. At sheepskin and pigskin tanneries.
	2. Fatliquoring	2. Oils and related fatty substances are applied to the leather to replace the natural oils lost in the beamhouse and tanyard processes. Most of the oil and grease materials are animal or vegetable based. Some tanneries use a very small amount of mineral based oil.

Continued.....

Table W8.8.1. (Continued)

Major pollutant or pollutant parameter	Processing step	Comments
TSS	1. Wash and soak	1. Includes sand, silt, clay, and manure.
	2. Trimming and fleshing	2. Hide scraps.
	3. Degreasing	3. Oil and grease.
	4. Unhairing	4. Hair.
	5. Chrome tanning	5. Chromium
	6. Retanning	6. Chromium
	7. Coloring	7. Constituents in organometallic dyes
	8. Fatliquoring	8. Oil and grease.
	9. Various processes	9. Suspended solids include adsorbed toxic organic pollutants such as solvents, constituents of dyes and finishes, tanning agents, and biocides all coming from several processes within the tannery.
pH	1. Unhairing	1. Plants which have these operations will invariably have excess alkalinity due to the presence of large quantities of lime.
	2. Bating	2. This step yields an acidic waste stream.
	3. Pickling	3. This step yields an acidic waste stream.

Continued.....

Table W8.8.1. (Continued)

Major pollutant or pollutant parameter	Processing step	Comments
Sulfide	1. Unhairing	1. Sulfide compounds are used extensively in the unhairing process. A significant portion of alkaline sulfides contained in tannery wastewater converts to hydrogen sulfide at a pH below 8.0, resulting in the release of this gas to the atmosphere. Careless mixing of acid and sulfide containing alkaline streams can be catastrophic within both tanneries and sewers.
Ammonia	1. Bating	1. Ionized ammonia is generated by spent bating liquors in a tannery.
TKN	1. Unhairing	1. Organic nitrogen is derived primarily from dissolved or pulped proteinaceous hair.

PSES. The treatment technology for complying with PSES is in-plant controls, including stream segregation and water conservation, chromium recovery and reuse, segregated stream pretreatment, including fine screening/equalization and catalytic oxidation of beamhouse wastewater; pH control and monitoring (pH and flow) at the combined sewer discharge; coagulation-sedimentation of tanyard wastewater; and dewatering of sludge. PSES includes control capability for sulfide and chromium.

The pollutants regulated by PSES are sulfide, total chromium, and pH.

PSNS. The treatment technology for complying with PSNS is the same pretreatment technology as that for PSES.

Costing Methodology

Water pollution control costs to the leather tanning and finishing industry for compliance with effluent limitations, pretreatment standards, and new source performance standards were developed using model plants of different sizes for the various industry subcategories. The models utilized to represent the industry, their respective sizes, capacities, and mode of discharge are shown in the Appendix. The cost equations and model plants used in the analysis were developed from data obtained in the Development Document. Table W8.8.2 summarizes the compliance costs for the leather tanning and finishing industry.

Table W8.8.2. Leather tanning and finishing industry

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	1.12	0.0	1.70	11.46	10.89
NEW PLANTS (NSPS)	0.0	0.0	0.0	1.97	6.31
PSES/PRETREAT	27.46	0.0	48.73	140.87	119.60
PSNS	0.0	0.0	0.0	0.0	8.66
TOTAL	28.58	0.0	50.43	154.30	145.46
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.22	0.0	0.30	3.08	12.05
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.51	4.03
PSES/PRETREAT	6.41	0.0	10.14	58.20	165.58
PSNS	0.0	0.0	0.0	0.0	2.26
TOTAL	6.63	0.0	10.44	61.79	183.92
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.70	0.0	0.94	9.90	38.74
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.14	2.06
PSES/PRETREAT	4.47	0.0	7.11	41.69	124.12
PSNS	0.0	0.0	0.0	0.0	1.40
TOTAL	5.17	0.0	8.05	51.73	166.32
ANNUAL CAPITAL + O+M	11.80	0.0	18.49	113.52	350.24
ALL ANNUAL COSTS	11.80	0.0	18.49	113.52	350.24

Chapter W9. Other Industries

This group of industries contains two point source categories:

- Pharmaceutical Manufacturing
- Hospitals

The costs developed for these two categories are summarized in Table W9. These costs and other data, assumptions, and details are discussed in the following subsections.

TABLE W 9. OTHER INDUSTRIES
INDUSTRIES WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF 1981 DOLLARS)

		INVESTMENT				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 9. 1	PHARMACEUTICAL MFG.	6.65	2.86	12.88	20.78	15.06
W 9. 2	HOSPITALS	43.39	293.07	121.63	271.47	702.54
	TOTAL INVESTMENT	50.05	295.93	134.52	292.25	717.60

		ANNUAL COSTS				
CHAPTER	INDUSTRY	1981	1972-78	1979-81	1979-84	1981-90
W 9. 1	PHARMACEUTICAL MFG.	5.69	2.94	10.40	36.13	82.87
W 9. 2	HOSPITALS	101.67	219.91	271.94	652.98	1667.99
	TOTAL ANNUAL COSTS	107.36	222.85	282.34	689.10	1750.86

Chapter W9.1 Pharmaceutical Manufacturing

Regulations

Interim final BPT regulations for the Pharmaceutical Manufacturing Point Source Category were promulgated on November 17, 1976 (41 FR 50676; 40 CFR Part 439) for five subcategories of the industry. These BPT regulations set monthly limitations for BOD_5 and COD based on percent removals for all subcategories; no daily maximums were established for these two parameters. The pH was set within the range 6.0 to 9.0 standard units. Average daily TSS values for any calendar month were established for three of the five subcategories; no TSS values were established for the remaining two subcategories. Subpart A, which is applicable to the fermentation operations, was amended on February 4, 1977 (42 FR 6814) to improve the language referring to separable mycelia and solvent recovery. In addition, the amendment allowed the inclusion of spent beers (broths) in the calculation of raw waste loads for Subpart A in those instances where the spent beer is actually in the wastewater treatment system. These regulations were never challenged.

Regulations expanding water pollution control requirements were proposed for the industry on November 26, 1982 (47 FR 53584). In this round of rulemaking, efforts were directed toward amending BPT based on a more complete data base and instituting BCT and BAT effluent limitations, new source performance standards (NSPS), and pretreatment standards for existing and new sources (PSES and PSNS respectively) that will result in reasonable further progress toward the national goal of eliminating the discharge of "classical" and toxic pollutants. The proposed regulations, however, do not require the installation of any particular technology. Rather, they require achievement of effluent limitations representative of the proper application of the recommended or equivalent technologies.

Industry Characteristics

Pharmaceutical manufacturing, using many different methods and raw materials to create a wide range of products, is one of today's more profitable industries. Products include medicinal and feed grades of organic chemicals having therapeutic value, whether obtained by chemical synthesis, fermentation, extraction from naturally occurring plant or animal substances, or refining a technical grade product. Pharmaceutical products, processes, and activities include:

- Biological products covered by the U.S. Department of Commerce, Bureau of the Census Standard Industrial Classifications (SIC) Code No. 2831.

- Medicinal chemicals and botanical products covered by SIC Code No. 2833.

- Pharmaceutical products covered by SIC Code No. 2834.

- All fermentation, biological and natural extraction, chemical synthesis, and formulation products which are considered as pharmaceutically active ingredients by the Food and Drug Administration, but are not covered by SIC Codes Nos. 2831, 2833, or 2834. Products of these types, such as citric acid, which are not regarded as pharmaceutically active ingredients, are included if they are manufactured by a pharmaceutical manufacturer with processes resulting in wastewaters closely corresponding with those from the manufacture of pharmaceutical products.

- Cosmetic preparations covered by SIC Code No. 2844 which function as a skin treatment. This group of preparations does not include products such as lipsticks and perfumes which serve to enhance appearance or to provide a pleasing odor and do not provide skin care. In general, this would also exclude deodorants, manicure preparations, and shaving preparations which do not primarily function as a skin treatment.

- Products with multiple end uses which are attributable to pharmaceutical manufacturing as a final pharmaceutical product, component of a pharmaceutical formulation, or a pharmaceutical intermediate. Products which have non-pharmaceutical uses may also be covered entirely by this point source category provided that they are primarily intended for use as a pharmaceutical.

- Pharmaceutical research includes biological, microbiological, and chemical research, product development, clinical and pilot plant activities, but excludes farms which breed, raise and/or hold animals for research at another site. Also excluded are ordinary feedlot or farm operations utilizing feed which contains pharmaceutically active ingredients.

EPA has identified 464 potential pharmaceutical facilities in the United States and its possessions. Approximately 70 percent of the plants with significant wastewater discharges are located east of the Mississippi River. Older plants are located in the Northeast and Midwest while newer facilities tend to be located in the nation's "Sun Belt." Puerto Rico contains almost ten percent of the total number of pharmaceutical facilities and is developing into a major center for pharmaceutical manufacturing.

Pharmaceutical manufacturers use four major kinds of manufacturing activity in the production of their products: fermentation, biological and natural extraction, chemical synthesis, and formulation. Over half of the pharmaceutical facilities surveyed (271) perform only formulation, a smaller number (47) are involved only in chemical synthesis, and a total of 42 plants use both chemical synthesis and formulation. The remainder of the plants perform fermentation, biological, or natural extraction, or a combination of activities.

Ten percent of the pharmaceutical facilities are direct dischargers, 53 percent are indirect dischargers, 21 percent are zero dischargers, and 16 percent utilize more than one mode of wastewater discharge.

The industry was first subcategorized during the development of the 1976 BPT guidelines into five product or activity areas based on distinct differences in manufacturing processes, raw materials, products, wastewater characteristics, and treatability. These subcategories were defined as:

Subcategory A - Fermentation Products

Subcategory B - Biological and Natural Extraction Products

Subcategory C - Chemical Synthesis Products

Subcategory D - Fermentation Products

Subcategory E - Pharmaceutical Research

Fermentation is the basic method used for production of most antibiotics and steroids. It is accomplished by preparing a seed, allowing the seed to ferment a batch of raw materials, and then recovering the desirable product by solvent extraction, precipitation, or ion exchange.

Biological and natural extraction involve the removal of pharmaceutical products from natural sources such as plant roots and leaves, animal glands, or parasitic fungi.

Chemical synthesis is used in the production of most drugs. They are prepared in batch reactors which can be used for many processes including heating, chilling, mixing, condensation, vacuum evaporation, crystallization, and solvent extraction. These reaction vessels are often constructed of stainless or glass-lined steel for corrosion resistance. This type of construction with the appropriate auxiliary equipment enables these vessels to be used for multiple functions. Since these reactors are versatile, many different compounds can be produced in any one vessel.

Formulation is the process by which pharmaceuticals are prepared into forms useable for consumers. These forms include tablets, capsules, liquids, and ointments. The active ingredients are mixed with filler, formed into a useable state (dosage quantities), and packaged for distribution.

Pharmaceutical research covers research in any of the active ingredients areas.

EPA reevaluated the 1976 subcategorization of the industry in light of newly acquired information to confirm the conclusions of the previous studies and to determine the possibilities of further subdividing or combining existing subcategories. As a result, EPA decided that no additional subcategories were needed and, in fact, there was no need to distinguish among the original subcategories. This decision was made after consideration of the following points.

- Most of the industry subject to regulation is composed of plants using more than one process. Wastewaters from all the processes are routinely combined before treatment for conventional and nonconventional pollutants. Additionally, the relative volumes of wastewater from the various processes are subject to considerable variation. Thus, since wastewater in most plants is not normally distinguishable by process, it is difficult to apply different limitations to different subcategories.

- The product/process diversity within each subcategory tends to obscure the distinctions between subcategories. In some cases, differences in pollutant loadings for plants within a subcategory may be greater than for plants from different subcategories. Subcategorization schemes along different product/process lines were considered, but were rejected as being too complex and not necessarily more accurate.

- Wastewater treatability at plants within each subcategory is not characteristically related to the product/process engaged in by each manufacturing subcategory. Conventional pollutant loadings for BOD_5 and TSS are generally amenable to reduction by biological treatment, regardless of their subcategory source. It has also been demonstrated that reduction to identical pollutant levels is achievable for wastewater from each of the different subcategories. Pollutant loadings may vary within each subcategory and across subcategories, but such differences may be addressed by design and operating modifications to the biological systems. This conclusion is evidenced by the fact that the current BPT regulation establishes identical limitations for each subcategory covered. The costs of treatment are a function of flow, raw waste load, and effluent level to be achieved and not process per se.

- The existing subcategorization scheme is irrelevant to the regulation of toxic pollutants for this industry. The occurrence of toxic pollutants in a plant's wastewater is not dependent on its process subcategory designation(s), but on the particular mix of individual product/processes.

- Available performance data as well as screening and verification sampling results for toxic pollutants suggest that the industry can be equitably regulated by a single set of limits. Therefore, one set of limitations and guidelines is proposed for the entire industry, excluding facilities which only perform research.

Pollutants and Sources

Wastewater discharges from pharmaceutical manufacturing facilities are not entirely related to the particular processes used. A significant portion of the wastewater from all four general process operations may consist of washwater from floor and equipment cleaning, spills from bulk processing, spent raw materials, and noncontact cooling water. Some wastewater may be generated as a result of the specific requirements of a particular process, e.g., air scrubber wastewater from some extraction processes.

The most commonly found pollutants or pollutant parameters in the effluent of pharmaceutical manufacturing facilities are:

a. toxic pollutants (cyanide, benzene, methylene chloride, toluene, chromium, copper, lead, mercury, nickel, and zinc),

b. conventional pollutants (BOD_5, TSS, and pH), and

c. the nonconventional pollutant parameter COD.

In addition to their adverse effect on water quality, aquatic life, and human health, these and other chemical constituents contribute to equipment corrosion, hazardous gas generation, treatment plant malfunctions, and possible problems in disposing of sludges containing toxic chemicals.

Following are the pollutants to be regulated by the 1983 proposed regulations for the pharmaceutical industry.

- BPT. The conventional pollutant TSS and the toxic pollutant cyanide will be controlled through implementation of the revision to the BPT regulation. TSS limitations replace existing limitations and will apply to all plants covered in the existing BPT regulation. Cyanide limitations are new and will apply to all plants covered in the existing BPT regulation except for pharmaceutical research facilities. Existing BPT limitations for BOD_5, COD, and pH are unchanged.

- BAT. The nonconventional pollutant parameter COD and the toxic pollutant cyanide will be controlled through implementation of the proposed regulation. Toxic metal and organic pollutants may be regulated on a case-by-case basis.

- BCT. Pollutants controlled by BCT regulation for the pharmaceutical industry include the conventional pollutants BOD_5 and TSS. The pollutant parameter pH is specified again as a range of 6.0 to 9.0.

- PSES and PSNS. Cyanide is controlled by PSES and PSNS regulations.

Control Technologies and Costs

Status of In-place Technology

Current treatment practices in the pharmaceutical industry include both in-plant and end-of-pipe pollution control technologies. Approximately 72 percent of direct dischargers have some type of end-of-pipe treatment system in place, 17 percent of direct dischargers utilize in-plant technology, and ten percent of direct dischargers have both end-of-pipe and in-plant control technologies in place.

The majority of those using end-of-pipe systems employ equalization and neutralization followed directly by biological treatment. In addition, some facilities use primary treatment, physical-chemical treatment, and other methods, e.g., polishing ponds and filtration.

The majority of plants utilizing in-plant controls rely on solvent recovery. In addition, some plants use cyanide destruction, chromium reduction and metals precipitation, steam stripping, and other allied treatment techniques. Solvent recovery techniques are widely practiced in the industry because of the economic value of reusing solvents. Some plants, in order to make reuse possible, try to use a small number of different solvents. When recovered solvent mixtures are too complex to be separated and reused, they are disposed of by incineration, landfilling, deep well injection and contract hauling. Wastewater containing significant amounts of volatile organic solvents may be treated by steam stripping. Preliminary studies indicate that steam strippers in use by the industry may reduce such commonly used solvents as benzene, 1, 2-dichloroethane, chloroform, ethylbenzene, methylene chloride, and toluene to a concentration level of 50 μg/1 and achieve a 55 percent reduction in the concentration level of phenol. Cyanide is destroyed by using chemical oxidation (alkaline chlorination or ozonation) and thermal/pressure techniques. Cyanide destruction systems in the pharmaceutical industry can achieve a long term average effluent concentration of 200 μg/1 total cyanide. This performance is confirmed by the results of similar studies in the metal finishing industry. Metals are treated by chromium reduction and either hydroxide or sulfide precipitation with concentration levels ranging from 100 to 500 μg/1 being achieved for various toxic metals.

Many new pharmaceutical plants are being built with in-plant source controls which may reduce the need for additional controls further downstream. Examples of in-plant source controls include modification of production processes, separation of wastes as they are produced, use of automatic pollutant detection equipment within the process, chemical or solvent substitution, material reclamation, and water reduction or recycle. Pharmaceutical manufacturers, however, cannot practice substitution of solvents or use of recovered chemicals as easily as other chemical manufacturers. FDA requirements specify that any recycled chemicals or solvents must meet the same specifications as virgin chemicals or solvents to be used in an FDA approved drug (active ingredient) manufacturing process. The substitution of a different solvent or chemical in an FDA approved manufacturing process may reopen the approval process for the drug involved. If contaminants are present in the recycled solvents, the manufacturer must prove to FDA that no deleterious effects result in the active ingredient and final product. Pharmaceutical manufacturing plants also are required by FDA to track by lot number all chemicals used in each process.

Cost Data

Capital and O&M costs were estimated exogenously using values reported in the 47 FR 53584 and the recent Development Document (EPA440/1-82/084). These costs are for BPT, BCT, BAT, PSES and NSPS and are as follows (in 1982 dollars):

	Capital costs	Annualized costs
BPT	$ 2,000,000	$ 723,000
BCT	21,800,000	8,500,000
BAT	0	0
PSES	1,000,000	379,000
NSPS	na	na
Total	$24,800,000	$9,602,000

The annualized cost includes both capital related costs and O&M costs. To make these costs compatible with ABTRES it was necessary to separate O&M costs from the annualized estimates. This was accomplished by reviewing the detailed costs presented in the Development Document.

Equipment is assumed to be replaced in 15 years and should represent 90 percent of the original capital costs. O&M costs are not expected to change significantly due to equipment replacement as reflected in the ABTRES input file.

Costs are summarized in Table W9.1.1.

Table W9.1.1. Pharmaceutical manufacturing

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .0

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	6.65	2.86	12.88	20.78	15.06
ANNUAL COSTS					
ANNUAL CAPITAL COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	2.07	1.12	3.81	13.13	30.03
ANNUAL O & M COSTS					
EXISTING PLANTS					
BPT	0.0	0.0	0.0	0.0	0.0
BAT	0.0	0.0	0.0	0.0	0.0
NEW PLANTS (NSPS)	0.0	0.0	0.0	0.0	0.0
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	3.62	1.82	6.59	23.00	52.84
ANNUAL CAPITAL + O+M	5.69	2.94	10.40	36.13	82.87
ALL ANNUAL COSTS	5.69	2.94	10.40	36.13	82.87

Chapter W9.2 Hospitals

Regulations

Only BPT regulations have been promulgated for hospitals, although other regulations have been proposed. The costs of compliance are based on promulgated and proposed regulations and have not been updated since it not known when BAT and NSPS regulations will be promulgated.

Industry Characteristics

The U.S. Hospital industry includes over 7,000 hospitals primarily engaged in providing diagnostic services, extensive medical treatment, surgical services, and other hospital services as well as continuous nursing services. Specific hospital types are:

- General medical and surgical hospitals
- Psychiatric hospitals
- Specialty hospitals except psychiatric hospitals; childrens hospitals; orthopedic hospitals; chronic disease hospitals; maternity hospitals; geriatric hospitals; eye, ear, nose, and throat hospitals; tuberculosis hospitals.

The vast majority of hospitals are nonprofit institutions in which expenses are recovered by charges for hospital services. Most hospitals are located in densely populated areas and discharge into municipal sewers. The Development Document estimated that approximately 90 percent of all hospitals discharge into municipal sewers. Table W9.2.1 presents estimated numbers of hospitals that have their own treatment facilities.

Table W9.2.1. "Direct discharger" hospitals*

Bed Size Category	Total Number of Hospitals	Estimated Number of Hospitals With Own Treatment Facilities
50-99	1,748	175
100-199	1,533	153
200-299	766	77
300-399	444	44
400-499	291	29
500 or more	634	63

*Assumption: Only 10% of all hospitals in each size category will have their own wastewater treatment facilities.

Source: "Hospital Statistics: 1975 Edition".

Pollutants and Sources

The primary sources of wastewater streams from hospitals include sanitary wastewaters, discharges from surgical rooms, laboratories, laundries, X-ray departments, cafeterias, and glassware washings. Wastewaters from hospitals can be characterized as containing BOD_5, COD, and TSS concentrations comparable to normal domestic sewage and readily amenable to biological treatment.

Specific contaminants in hospital wastewater include mercury, silver, barium, beryllium, and boron. Mercury is used in laboratories, silver and boron result from X-ray development. Barium is used in diagnostic work and beryllium is used in dental clinics.

Control Technology and Costs

The technology for the control and treatment of waterborne pollutants in the hospital industry can be divided into two broad categories: in-plant control and end-of-pipe control.

Specific in-house control practices that are applicable to the hospital industry include: recovery of silver from spent X-ray developer, prevention of discharge of volatile solvents and toxic chemicals into drains, and restriction of the discharge of mercury-containing compounds into the sinks and drains.

To meet the proposed NSPS and BAT regulations, end-of-pipe treatment technologies equivalent to biological treatment followed by multi medi filtration are recommended.

Relatively few hospitals treat their wastewater since most hospitals are located near urban areas. Of the hospitals that treat their own wastewaters, the most prevalent end-of-pipe wastewater treatment system is the trickling filter plant; however some hospitals used activated sludge treatment systems.

Treatment costs are summarized in Table W9.2.2.

Table W9.2.2. Hospitals

WATER POLLUTION CONTROL COSTS
(IN MILLIONS OF DOLLARS)
CAPITAL IN PLACE (KIP): .187E+09

	1981	1972-78	1979-81	1979-84	1981-90
INVESTMENT					
EXISTING PLANTS					
BPT	0.0	76.97	0.0	0.0	21.18
BAT	0.0	62.10	0.0	0.0	38.47
NEW PLANTS (NSPS)	43.39	154.00	121.63	271.47	642.89
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	43.39	293.07	121.63	271.47	702.54
ANNUAL COSTS					
ANNUALIZED CAPITAL					
EXISTING PLANTS					
BPT	10.12	30.46	30.36	60.72	100.87
BAT	8.16	34.85	24.49	48.99	80.88
NEW PLANTS (NSPS)	36.24	57.93	91.98	239.19	694.27
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	54.52	123.24	146.83	348.89	876.02
O + M					
EXISTING PLANTS					
BPT	8.11	24.41	24.33	48.66	81.56
BAT	3.68	15.74	11.03	22.06	25.80
NEW PLANTS (NSPS)	35.36	56.52	89.75	233.37	684.60
PSES/PRETREAT	0.0	0.0	0.0	0.0	0.0
PSNS	0.0	0.0	0.0	0.0	0.0
TOTAL	47.14	96.68	125.11	304.09	791.97
ANNUAL CAPITAL + O+M	101.67	219.91	271.94	652.98	1667.99
ALL ANNUAL COSTS	101.67	219.91	271.94	652.98	1667.99

Chapter W10. Nonpoint Sources

During the 1979 oversight hearings on the Clean Water Act, Congress concluded that: "the attainment of a goal of 'fishable' swimmable' waters is highly dependent on the degree to which nonpoint pollution can be controlled...". However, controlling nonpoint sources, primarily agricultural runoff, urban runoff, silvicultural runoff, and mine drainage is extremely difficult, both technically and politically. Technically, controlling pollutants carried from the surface of the land into waterways by rain and snowmelt requires careful consideration of such site-specific factors as soil type, crop type, slope, and proximity to water body. Politically, an effective control program must consider how implementation will be achieved; through regulation, technical assistance education, or cost-sharing.

The need to tailor both control techniques and implementation strategies to the particular needs of specific sites makes the use of a nationally uniform technology based standard, such as those mandated by Congress to control pollution emitted from point sources, (i.e. industrial and municipal discharge pipes) impossible. Instead, in 1977 Congress mandated that each state develop and implement a plan for achieving state water quality goals. State water quality plans were supposed to provide states with a vehicle for addressing the nonpoint source problem on a site-specific basis. However during the formulation of these plans states discovered a serious lack of information concerning the effectiveness of the various control options. Due to this lack of information, and a lack of incentives and financial resources, very few states have actually implemented their water quality plans. As a result nonpoint source pollution was identified as the most serious cause of water quality problems in six out of ten EPA Regions (1983 Environmental Management Reports).

The lack of verifiable cause-and-effect information, and the necessity for control programs to be individually designed, also makes it difficult to estimate the national cost of controlling nonpoint source pollution. Nevertheless, a variety of governmental agencies and private organizations have attempted to provide national cost estimates. This chapter provides an overview of these estimates. Although it is the best available information, in many cases the data are unverified and further work remains to be done. Thus, this report should be viewed as illustrating the range of costs for implementing a variety of control strategies--not as projected estimates of actual investments. A single estimate of non-point source control costs will not be presented.

The benefits associated with each cost estimate also vary. The lower level, less expensive control options will achieve state water quality goals either to a limited extent in the near term or fully over a greater length of time. The higher level, more expensive options are designed to fully comply with water quality goals in a shorter time frame.

However, the lower level options are expected to achieve greater reductions in pollutant loads per dollar spent and will result in improved water quality, if not meeting the standards in all cases.

The following sections present and compare the costs of different options for controlling water pollution from agricultural, silvicultural, and urban nonpoint sources. This chapter also contains a section discussing the cost of administrating and implementing a nonpoint source program. All costs are in 1981 dollars.

Agricultural Control Costs

Runoff from agricultural lands is the largest and most pervasive contributor to the nonpoint pollution problem. Over half of the total man-made sediment load results from agricultural activities. Agricultural activities also contribute significant amounts of nitrates, phosphorus, various pesticides, and salts. Most techniques for controlling agricultural runoff require the farmer to alter current management practices. For example, the most commonly used erosion control practice or 'best management practice' (BMP) is conservation tillage; a technique whereby the farmer reduces land disturbances by reducing the amount of plowing and discing. Other techniques, such as building a detention basin to catch runoff, require the farmer to make structural changes. Structural techniques are usually extremely expensive while nonstructural techniques may even increase farm profits.

In 1980 the U.S. Department of Agriculture completed a Soil and Water Resources Conservation Act (RCA) Appraisal. Based on the results of this study it is possible to estimate the cost of controlling agricultural pollution in three different ways. The first is to install all the practices necessary to prevent soil erosion. The second is to modify the erosion control program to focus on water quality problems. The third is to install only nonstructural control techniques.

It is also possible to estimate the cost of implementing a national conservation tillage program. This would be the least expensive manner of controlling agricultural pollution short of leaving fields in uncultivated, unforaged pasture. The national conservation tillage estimate is based on a demonstration program recently completed in the western basin of Lake Erie.

1980 Soil and Water Resources Conservation Act Appraisal

According to the 1980 Soil and Water RCA appraisal, a nationwide program to control agricultural nonpoint source pollution would cost about $7.3 billion over ten years (see Table W10.1). All water quality problems resulting from agricultural nonpoint sources would be well controlled by this option. This estimate includes the application of both structural and nonstructural control practices to control erosion throughout the nation. Cost-sharing and educational and technical assistance would be utilized to ensure BMP implementation.

Table W10.1

Cost of 10 year program to control agricultural NPS pollution
(RCA projections in billions of $)

Program Segment	Billions of 1981 dollars
Problem Identification*	.4
Planning*	.3
Research*	.5
Technology Transfer*	.8
Application of Controls (BMPs)	5.1
Enforcement	.2
Total Federal & State Costs	7.3
Annual Cost	.73†

* Federal support programs.
† Costs are not amortized for this estimate or any of the options.

1980 RCA Appraisal Modified to Focus on Water Quality

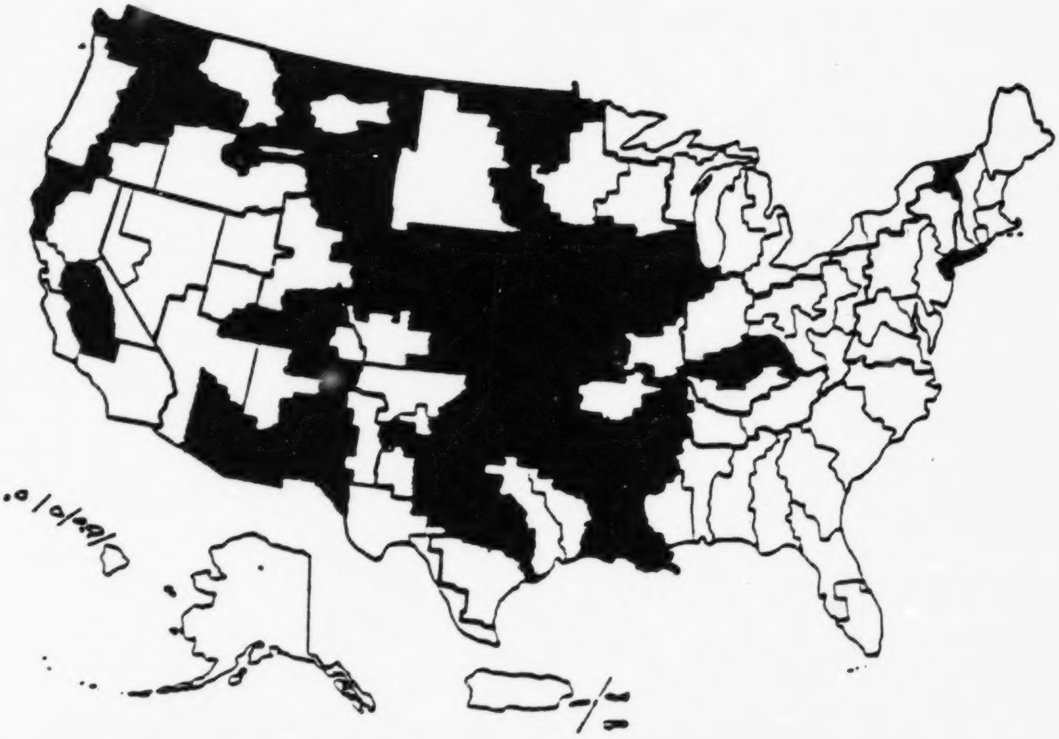
The $7.3 billion RCA erosion control projection can be modified by focusing implementation on only those areas needing controls to improve water quality, as opposed to controlling all erosion problems. This would reduce the cost for application of controls to approximately $5.8 billion over the ten year life of the program. Application would be ensured through a program of cost-sharing. Identification of the critical areas requiring nonpoint source controls to protect water quality is based on a 1980 evaluation of the 105 agricultural producing areas completed by Resources for the Future (RFF)(See Figure 1).

The procedures and estimates used by USDA for the RCA appraisal and the delineation of critical areas were combined to arrive at the modified estimate below (See Table W10.2). These figures are based on observed field values for the cost per critical acre to control selected pollutants. Sediment control figures are based on the expenditure required to reduce sediment reaching streams to .2 tons/acre.

As sediment is controlled, so is a portion of the toxics and nutrients which are attached to soil particles. To compensate for this overlap factor, the costs for nutrient and toxics control are reduced by 50%.

FIGURE 1

Critical areas where potential for degraded water quality is high due to agricultural NPS pollutants



*Source: USDA. "1980 RCA Appraisal Part II."

Table W10.2. Annual costs to control agricultural NPS pollutants

Pollutant	Critical areas	Annual control cost	Overlap factors	Total annual cost ($000,000) 1981 dollars
Sediment	70 million acres	$4.50/acre	N/A	$315
Nutrients	10 million acres	$4.50/acre	50%	23
Toxics	85 million acres	$5.40/acre	50%	230
Organic wastes	1,550 systems/yr	$9k/system	N/A	14
			Total Annual Cost	$582

1980 RCA Appraisal Modified to Only Nonstructural Techniques

The second way to modify the RCA appraisal erosion control cost is to limit cost-sharing of management practices to nonstructural control measures. Structural control techniques, for example terracing, are expensive and appear to be less cost-effective than nonstructural control measures. This modification would reduce the cost for application of controls to approximately $2.7 billion over the ten year life of the program. However, this type of reduction would also limit the program's effectiveness.

National Conservation Tillage Program Estimate

In 1973 the U.S. Army Corps of Engineers implemented a program to provide educational and technical assistance in conservation tillage for farmers in the western basin of Lake Erie. This demonstration program is the basis for the development of the Conservation Tillage Program estimates in Table W10.3. These estimates are based on applying the costs identified in this project to the critical areas identified in the RFF study.

The demonstration project also found that implementation of an Integrated Pest Management (IPM)(Column F) program is recommended for 45 percent of the critical areas. Costs for an IPM program involving educational and technical assistance to farmers were estimated by reviewing similar cost data. Also, nutrient management was found to be essential for controlling NPS pollution from 50 percent of the critical areas. Costs for a nutrient program similar to the IPM program were estimated nationally in Column G.

State Program Management Costs

The FY 1979 EPA Water Quality Management Needs Survey projected state needs for implementing an agricultural NPS control program. This

Table W10.3. Program costs for controlling agricultural NPS pollution
(First 10-years of a 20-year implementation phase for cropland)

(A) Crop production region	(B) Cropland (10^6 ac)	(C) Cropland needing conservation treatment (10^6 ac)	(D) Critical acres requiring treatment (36% of (C)) (10^6)	(E) Conservation tillage program @ $2.49/ac (100% of (D)) ($\$10^6$)	(F) Integrated pest management @ $13.50/ac (45% of (D)) ($\$10^6$)	(G) Integrated pest management @ $13/.50ac (45% of (D)) ($\$10^6$)	(H) Total cost (E)+(F)+(G)=(H) ($\$10^6$)
Northeast	16.9	10.2	3.7	$ 9.2	$ 22.5	$16.7	$ 48.4
Appalachia	20.8	14.0	5.0	12.5	30.4	22.5	65.4
Southeast	17.5	12.5	4.5	11.3	27.4	20.3	59.0
Lake States	44.1	21.3	7.7	19.2	46.8	34.7	100.7
Corn Belt	89.9	64.9	23.4	58.3	142.2	105.3	305.8
Delta States	21.2	18.5	6.7	16.7	40.7	30.2	87.6
Northern Plain	94.6	44.6	16.1	40.1	98.1	72.5	210.7
Southern Plain	42.2	24.5	8.8	22.0	53.5	39.6	115.1
Mountain	42.2	24.1	8.7	21.7	52.8	39.2	113.7
Pacific	23.2	11.7	4.2	10.4	25.6	18.9	54.9
20 Yr. Total Cost	413	246	88.8	$221.4	$540.0	$399.9	$1,161.3
10 Yr. Total Cost							$ 580.7
Annual Cost							$ 58.1

needs survey estimated that $95* million, over a four year period, or $24 million annually (non-amortized), would be necessary to identify problems, and develop and administer a nonpoint source program. This would fund state programs ranging in size from $6,683 to $6.1 million annually. The average annual program cost is $387,585 and utilizes eleven staff years. The program size and corresponding management costs are based on the magnitude of the NPS problem identified in each state.

Comparison of Total Agricultural Program Costs

Total annual NPS control costs are estimated to range from approximately $58 million for a relatively low-level conservation tillage educational program to $734 million for a comprehensive cost-sharing program that includes program management, technical assistance, training, education, and cost-sharing for BMPs (See Table W10.4).

Table W10.4. Total annual control costs for agricultural NPS
(Costs in millions of 1981 dollars)

Control options	State program management cost*	Control costs	Total costs
Option 1 - RCA Control Program Estimate	$24	$734	$758
Option 2 - RCA Control Costs Modified to Focus More on Water Quality	24	581	605
Option 3 - RCA Control Program Estimate for Nonstructural BMPs	24	266	290
Option 4 - National Conservation Tillage Program	24	58	82

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* The State Program Management Cost does not take into consideration the varying control levels of the estimated programs (i.e., higher levels of control will require higher levels of state program management). Added management costs are included in some of the higher level control cost options. Comprehensive evaluation of management costs is beyond the scope of this assessment.

Silvicultural Sources

Forty states have identified silvicultural NPS pollution as a significant or potential problem (see Figure 2). Most of these states employ a voluntary approach to encourage the use of best management practices. The remainder use a regulatory approach; applying existing water quality regulations to forest lands. Resource requirements for these types of programs are modest, usually consisting of the addition of a water quality specialist to the State Forester's staff and increasing training materials and resources.

There are two distinct components of a silvicultural nonpoint source control program; program management and application of best management practices. These costs will be discussed individually and then combined to indicate total program costs.

Program management Costs

The administrative costs associated with the 'start-up' of a silvicultural control program, either voluntary or regulatory, will be significantly higher than costs in subsequent years. Administrative costs will decrease as voluntary programs are developed and carried out, and as staff members are hired and trained. Conversely, regulatory programs will have higher costs for enforcement, staff, and equipment. These costs are generally fixed and continuing.

Table W10.5 shows program costs for two levels of effort for the 35 voluntary (and quasi-regulatory) program states. Level 2 provides for an enhanced program that would result in additional work such as BMP evaluation and more rapid implementation.

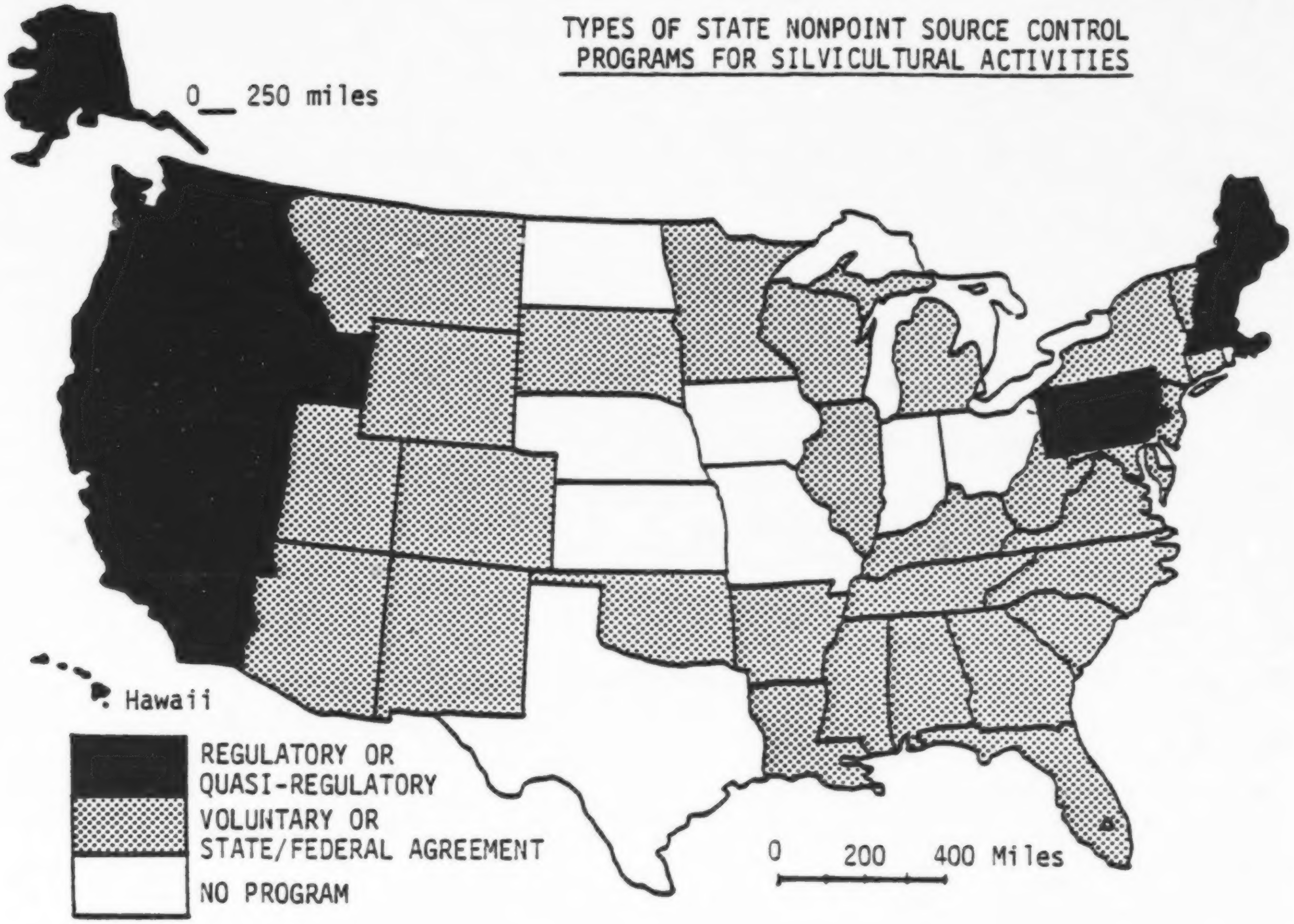
Cost of Applying Controls

Most water quality problems occur when steep slopes and fragile soils are disturbed for timber harvesting or road building. Every year approximately 4 million acres of harvest area are so disturbed that some application of BMP--either land treatment or management techniques is required. Those areas needing controls are defined as critical areas.

The cost of applying controls ranges from $2.25 per acre for low-level treatment to a high of $12.60 per acre. These costs are for activities such as seeding unused road beds or constructing water barriers on skid trails and roads. The high-level treatment also includes operation and maintenance costs associated with structural control measures.

Table W10.6 identifies the major timber harvesting regions in the nation, their annual harvest areas, critical acreages within the harvests, the percentage of high and low-cost BMPs in use, and the total cost for their application.

Figure 2


TYPES OF STATE NONPOINT SOURCE CONTROL PROGRAMS FOR SILVICULTURAL ACTIVITIES

0 250 miles
Hawaii
REGULATORY OR QUASI-REGULATORY
VOLUNTARY OR STATE/FEDERAL AGREEMENT
NO PROGRAM
0 200 400 Miles

CONTROL APPROACH

REGULATORY

Alaska
California
Idaho
Oregon
Washington

QUASI-REGULATORY

Hawaii
Maine
Nevada
New Hampshire
Pennsylvania
Massachusetts

VOLUNTARY

Alabama
Arizona
Arkansas
Colorado
Connecticut
Florida
Georgia
Illinois
Kentucky
Louisiana
Maryland
Michigan
Minnesota
Mississippi
Montana
New Jersey
New Mexico
New York
North Carolina
Oklahoma
South Carolina
South Dakota
Tennessee
Utah
Vermont
Virginia
West Virginia
Wisconsin
Wyoming

Reference: "Nonpoint Source (NPS) Water Pollution Control Needs and Costs" (Draft), 8-19-83, prepared by US EPA Office of Water Program Operations, Water Planning Division.

Table W10.5. Costs of administering voluntary and regulatory programs for controlling silvicultural NPS pollution (in millions of 1981 dollars)

Year	Program costs for voluntary states		Program costs for regulatory states	Total national program cost	
	Level 1	Level 2		Level 1	Level 2
1st	$ 1.58	$ 3.78	$ 4.68	$ 6.26	$ 8.46
2nd	1.11	3.33	4.68	5.79	8.01
to	1.11	3.33	4.68	5.79	8.01
20th	1.11	3.33	4.68	5.79	8.01
20 Yr.Total Costs	22.67	67.05	93.60	116.21	160.65
10 Yr.Total Costs	11.34	33.53	46.80	58.11	80.33
Average Annual Costs	$ 1.13	$ 3.35	$4.68	$ 5.81	$ 8.03

NOTE: Both levels include the costs of developing an educational and information training program. For each of the 35 voluntary states, level 1 accounts for one man year per state, and level 2, for three man years per state.

Table W10.6. Timber harvest areas, critical areas and costs of treatment
(millions of acres and dollars)

Region	Harvest area	Critical areas	% LOW treatment	LOW treatment cost	%HIGH treatment	HIGH treatment cost	Total cost
Northeast	4.99 ac	1.25 ac	40%	$ 1.13	60%	$ 9.45	$10.6
Southeast	11.6 ac	2.3 ac	75%	$ 3.88	25%	$ 7.25	$11.1
Rocky Mountain	.27 ac	.12 ac	20%	$ .05	80%	$ 1.21	$ 1.3
Pacific Coast	.9	.36	10%	$ .08	90%	$ 4.09	$ 4.2
Total Annual Treatment Costs				$ 5.14		$22.00	$27.2

Total Cost for Controlling Silvicultural NPS Pollution

The estimated cost of controlling silvicultural NPS pollution is approximately $33.5 - to $35.7 million annually for the 10-year program. This includes the annual cost of administering voluntary, quasi-depending on the level of support as well as the annual cost of applying control measures ($27.2 million) on the 4 million acres of land disturbed by silvicultural operations.

Costs of Controlling Water Pollution from Urban Storm-Water and Construction

Storm-water runoff from built-up urban areas and erosion from urban construction sites are significant nonpoint sources of pollution. According to the Aquatic Life Survey, (EPA, 1982) urban storm-water affects about 20% of the river miles across the nation, and construction about 3%. The problems associated with sedimentation from construction sites are visible, and the control methodologies are well understood and proven. In contrast there has been some confusion over the exact nature and extent of water quality problems caused by urban stormwater and the effectiveness of available control measures. The next two sections examine these threats to water quality and the costs of controlling them.

Controlling Runoff of Urban Storm Water

In light of the unknowns associated with urban runoff, EPA initiated its Nationwide Urban Runoff Program (NURP) to improve available information on sources of urban sedimentation and their effects on water quality. The NURP funded monitoring projects at 28 sites throughout the nation. Preliminary results indicate that water quality problems arising from urban storm-water runoff, and the control measures to prevent or alleviate such problems, are heavily site-specific and therefore must be approached from that perspective (U.S. Environmental Protection Agency, "Draft Final Report of the Nationwide Urban Runoff Program: Volume I." (1982).

A wide range of technologies exists for controlling urban runoff. They can be as simple as straw bales to catch sediments in runoff or as complex as physical and chemical treatment and chlorination. All can be effective depending on circumstances. However, based on the NURP findings, it would be difficult to justify a national program to construct separate treatment plants for storm sewer discharges.

In developing and redeveloping areas, the quality of urban runoff can be controlled easily for a moderate cost. Developments can be designed to decrease runoff by using natural drainage systems, greenways, infiltration trenches, and porous pavement to increase infiltration. Detention basins have been found to be one of the more cost-effective practices for the long-term control of urban runoff. This conclusion is based on actual monitoring over several years of the performance of eleven detention basins by NURP. Reductions of up to 95 percent of most conventional pollutants were obtained in these detention basins.

The NURP projects also demonstrated that the type of receiving water body is significant in determining costs. For example, urban runoff causes the biggest problems in quiescent water bodies, such as lakes. Lakes are natural sinks that collect and store pollutants. In contrast, urban runoff is less of a problem in large rivers with moving water or in the oceans where dilution is great. It follows that less controls are needed to protect rivers and oceans than lakes.

The level of control necessary is also dependent on the desired benefit from improving quality: aesthetics, fish and wildlife, and/or recreation.

The level of control, and consequently the cost of control, is highly dependent on the effectiveness of the detention basin. One of the critical factors in the effectiveness of detention basins is the ratio between the area of drained urban surface to the detention basin's volume. Generally, the greater the volume relative to the drained urban surface, the greater the basin's efficiency in removing pollutants. Based on this finding, a method was developed in the NURP study to determine the level of control by the basin's volume. Specifically, detention basin costs were estimated for achieving a 40 percent reduction for aesthetics, 85 percent reduction for fish and wildlife, and 95 percent reduction for recreation. Based on the above assumptions, Table W10.7 and W10.8 summarize the cost estimates for urban runoff control. Table W10.9 breaks down the cost of treatment based on water body type.

Table W10.7. Option 1 - Total cost of controlling storm sewer discharges from all urban areas (13.2 million acres)*
(in millions of 1981 dollars)

Beneficial use	Capital	Annual O & M Costs*
Aesthetics	$1,141.	$ 46.
Fish and Wildlife	3,623.	145.
Recreation	11,498.	460.

* Annual O & M is 4 percent of capital costs.

Table W10.8. Total capital costs of controlling storm sewer discharges by receiving water body type (in millions of 1981 dollars)

Beneficial Use	Streams <10'	Rivers >10'	Lakes	Estuaries	Oceans	Total
Aesthetics	$233.	$ 318.	$357.	$ 233.	$0	$ 1,141.
Fish and Wildlife	933.	1,399.	357.	933.	0	3,623.
Recreation (includes disinfection)	3,273.	4,549.	402.	3,273.	0	11,498.

Since lakes and estuaries are particularly affected by urban runoff, the above estimates could be modified to emphasize control of urban runoff to such surface waters.

Table W10.9. Total cost for controlling urban stormwater runoff (in 1981 dollars)

	Cost
Option 1 - Total Cost of Controlling Separate Storm Sewer Discharges from All Urban Areas	$ 1,141. million (Aesthetics) $ 3,623. million (Fish & Wildlife) $11,498. million (Recreation)
Option 2 - Total Cost of Controlling Separate Storm Sewer Discharges to Lakes and Estuaries	$ 590. million (Aesthetics) $ 1,290. million (Fish & Wildlife) $ 3,669. million (Recreation)
State Level Program Management Annual Costs	$4-$13.2 million
Local Level Program Management Annual Costs	$22.5 million

Urban Runoff Program Management Costs

To oversee the types of storm-water quality controls discussed above, states would initially need extensive resources. EPA's 1980 Needs Assessment projected a cost of $13.2 million (in 1981 dollars) for FY 1984. The costs of managing such a program would decrease after a state passes legislation requiring storm-water quality controls or after major urban areas adopted local ordinances.

Total Costs for Urban Runoff Control

Table W10.9 summarizes the total cost for controlling urban stormwater runoff. The program management costs are estimated as annual costs while the cost of controlling urban runoff is based on total urban control needs.

Controlling Runoff From Urban Construction

Every year approximately 1.5 million acres of land are disturbed for constructing houses, factories, and other facilities. Although this figure is relatively small, the sediment loadings from construction sites are higher than those from most land uses. Erosion rates of 30-200 tons/year/acre--or 10-20 times that of cropland--are reported in the literature. Consequently, even small amounts of construction may significantly affect local water quality.

Sediment is the primary pollutant of concern from construction sites. In addition, such materials as pesticides, cleaning solvents, concrete compounds, asphalt, salts, and petroleum products are frequently washed from building sites and carried to surface waters.

Technical and institutional solutions to construction erosion problems are relatively straight-forward and well-understood. Many states have technical manuals explaining how to control erosion from construction sites. Technical measures include such vegetative or mechanical practices as seeding and mulching, straw bale barriers, diversion ditches, and sediment basins installed on site. Institutional laws and ordinances are necessary because such measures are rarely carried out unless required by law.

Regulatory programs to control construction runoff have been increasing gradually in the United States since 1967, when Montgomery County, Maryland, instituted the first mandatory control program. About fifteen states, the District of Columbia, and the Virgin Islands have developed effective regulatory programs. These regulatory programs typically require local jurisdictions (counties, towns, cities, and villages) to adopt and enforce local construction erosion ordinances that meet minimum standards. Several of the state programs predate the Clean Water Act and are funded largely from state and local revenues and permit fees.

Cost Estimate for Construction Control Program Management Costs

The estimated program costs for controlling construction erosion include the program costs of managing the program and applying the needed controls at the state and local levels.

Cost estimates for state and local program management are based on the State of Maryland's program for controlling sediment. We choose Maryland because its program is good and data on manpower was readily available.

In estimating the program management cost we made the following assumptions:

- The number of staff required in Maryland is the basis for staff estimates in other states. However, local inspection personnel were increased by 20 percent, as an evaluation of Maryland's program indicated that inspection was weak.
- Salaries were estimated at $18,000 for plan reviewers, $15,300 for inspectors, and $9,000 for secretaries, with 35 percent overhead.
- The populations of States were used to correlate Maryland's program with those needed for other states.
- Construction erosion control regulatory programs can be partly self-sustaining; program management at the local level should be recovered through construction permit fees.

Given the above assumptions, the number of state and local program management staff were estimated for each state (see Table W10.10). A total of $14,499,000 was estimated for state program management staff and $93,152,700 for local program management staff, totalling $107,651,700 per year. Dividing that total by the approximately 1.5 million acres of land used annually for construction yields an annual program cost of $72 per acre. Because a large percentage of the local program costs can be recovered through construction permit fees, there is no need for any type of cost sharing. However, state program costs are not similarly recoverable.

Industry's Costs for Applying Controls

The cost for controlling erosion has been estimated by DOW Chemical Company at $2,374 per acre. Thus, the annual estimated cost to the construction industry to control erosion from all of the disturbed construction sites across the nation is $3,561 million per year. These costs are typically included in construction prices and are generally not cost shared by federal, state or local governments.

Table W10.11 summarizes the total annual costs for construction erosion control. The total of $3,669 million includes the annual cost for administering construction erosion control programs at both the state and local levels and the cost to the private sector for applying control measures.

Table W10.10. Annual state and local program management costs for NSPS construction regulatory programs

	State Program Management (including state project plan reviewers, program management, secretaries)		Local Program Management (including plan reviewers, inspectors, and secretaries)	
State	Person years	Costs	Person years	Costs
MARYLAND*	8	$ 320,400	97	$2,052,000
1. Alabama	7	304,200	89	1,892,700
2. Alaska	1	36,000	9	194,400
3. Arizona	5	205,200	62	1,322,100
4. Arkansas	4	165,600	52	1,112,400
5. California	33	1,205,100	365	7,718,400
6. Colorado	5	205,200	66	1,405,800
7. Connecticut	6	229,500	71	1,512,000
8. Delaware	1	36,000	14	289,800
9. District of Columbia	1	36,000	15	313,200
10. Florida	12	484,200	150	3,176,100
11. Georgia	10	417,600	125	2,659,500
12. Idaho	2	72,000	21	452,700
13. Illinois	14	581,400	176	3,723,300
14. Indiana	10	417,600	126	2,672,100
15. Iowa	6	229,500	67	1,417,500
16. Kansas	4	165,600	54	1,150,200
17. Kentucky	7	304,200	84	1,782,000
18. Louisiana	8	320,400	96	2,045,700
19. Maine	2	72,000	25	547,200
20. Maryland	8	320,400	97	2,052,000
21. Massachusetts	10	417,600	131	2,791,800
22. Michigan	12	484,200	143	3,018,600
23. Minnesota	8	320,400	93	1,984,500
24. Mississippi	5	205,200	57	1,226,700
25. Missouri	9	364,500	113	2,393,100
26. Montana	2	72,000	18	386,100
27. Nebraska	3	109,800	36	711,000
28. Nevada	2	72,000	18	386,100
29. New Hampshire	2	72,000	21	452,700
30. New Jersey	9	364,500	113	2,401,200
31. New Mexico	3	109,800	30	632,700
32. New York	22	893,700	271	5,724,900
33. North Carolina	11	446,400	135	2,859,300
34. North Dakota	1	36,000	15	313,200
35. Ohio	13	550,800	166	3,520,800
36. Oklahoma	6	229,500	69	1,472,400
37. Oregon	5	205,200	60	1,280,700
38. Pennsylvania	15	603,900	183	3,869,100
39. Rhode Island	2	72,000	22	460,800
40. South Carolina	6	229,500	71	1,517,400
41. South Dakota	1	36,000	16	335,700
42. Tennessee	7	304,200	105	2,233,800
43. Texas	18	721,800	220	4,660,200
44. Utah	3	109,800	34	711,000
45. Vermont	1	36,000	12	248,400
46. Virginia	10	417,600	122	2,601,900
47. Washington	8	320,400	95	2,000,700
48. West Virginia	4	165,600	44	948,600
49. Wisconsin	9	364,500	108	2,289,600
50. Wyoming	1	36,000	11	228,600
Total	362	$14,499,000	4,393	$93,152,700

* Program developed from this state.

Table W10.11. Total annual cost for controlling construction NPS pollution costs (in millions of 1981 dollars)

Types of Cost	
State Program Management Costs	$ 14.5
Local Program Management Costs	93.2
Costs to Industry for Applying Controls	3,561.3
Total Annual Cost	$3,669.0